# ELECTRICAL REVIEW

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### The Remedy for "Busy" Telephones.

IN KANSAS CITY THE SUBSCRIBERS PUT IN ANOTHER TELEPHONE TO BE USED EXCLUSIVELY FOR CALLING.

The western people are enterprising ever. A great deal of good electrical work has had its origin west of the Mississippi. The telephone fraternity have been in the front rank with their work, and now the Kansas City subscriber, aided by advice from the company, has found a remedy which prevents his own telephone from being busy when he wants to use it himself. There are, we believe, more calls per telephone per day in Kansas City than in any city in the world, and some of the instruments are in almost constant use during business hours. There are some business concerns—railway offices, wholesale drug houses and express offices—that find their telephones in use so much by calls from other telephones that no opportunity is given for the telephone renters themselves to call up other people. To remedy this they have put in what they call a silent wire. That is, a telephone the number of which does not appear in the telephone list book. This instrument the subscriber uses exclusively for calls originating in his office, and receives on the other instrument—the one noted in the list.

This, of course, means an additional expense to the subscriber, in fact, doubles his telephone bill, yet this is a small item when the saving in time to a busy house is considered. The one drawback would be that this method does not prevent the telephone that may be called for from being "busy," and that is one of the things that can only be remedied by additional telephones for the complete service—or the invention of the duplex telephone.

### BOOK NOTICES.

"Third Annual Report of the West End Street Railway Company," of Boston, has been received.

We have received circulars announcing that the London *Electrician's* "Electrical Trades Directory and Hand-Book" for 1891, will appear in January, corrected up to December, 1890.

"Allen's Reference Telegraph Code" is a system for ordering from price lists, catalogues, etc., the code words being Latin roots, with references, having endings of uniformly four letters with references. It is an extremely ingenious method, designed to save time and money when ordering goods by telegraph. There are two editions of the book, one unabridged and the other abridged. Mr. Allen has applied for a patent on the system.

"The Dangers to Firemen from Electric Light Wires in Buildings," and "By-Products of Experience," by Allan R. Focte. are embodied in one pamphlet, which has been received with the compliments of the author. Notwithstanding his duties as secretary of the National Electric Light Association, Mr. Foote often finds time to give the electrical fraternity facts and ideas well worthy their attention.

"Transactions of the American Institute of Electrical Engineers, for October, 1890," contains: "Efficiency of Transformers," by Calvin Humphrey and W. H. Powell, and "Notes upon Some Experiments with Alternating Current Apparatus," by Professor Harris J. Ryan. A catalogue of membership, revised to November, 1890, is also given. The total number of members is 488, divided as follows: Honorary, 3; members, 151; associate members, 334.

"Electricity in Daily Life." The series of articles on electricity recently concluded in *Scribner's Magazine* forms the volume before us. Any one can enjoy reading these articles and be instructed thereby. They are written in a popular manner, but are equally interesting to the electrician or to those desiring a clearer insight into and general information about the wonders of electricity. Some of the brightest men in the electrical field to-day are the authors of these articles.

### Protesting against Overhead Railway Wires.

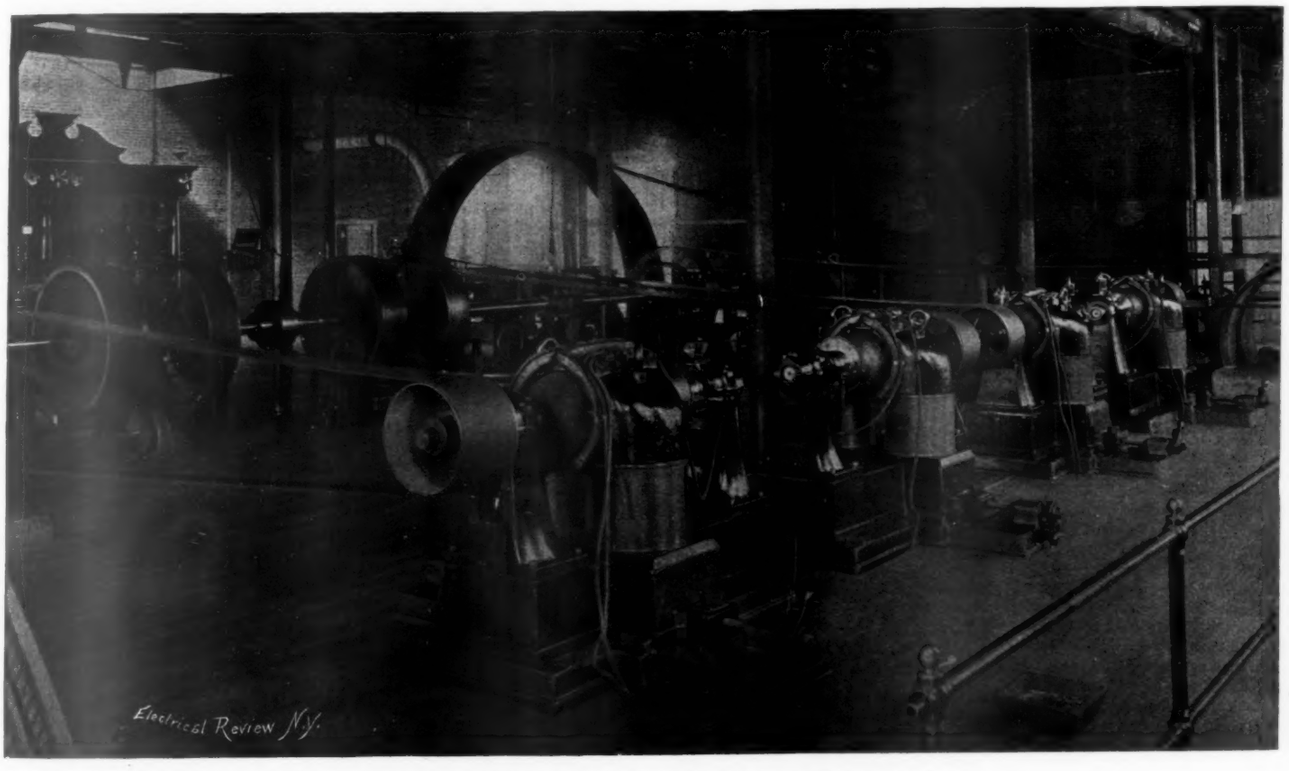
Property owners in the Eastern District of Brooklyn are protesting against the use of overhead wires for electric street car traction. "There has been some fear," says a daily paper, "that the people might not fully understand the danger of the overhead electric system until it was too late. That fear is shown by this meeting to have no foundation." We should have thought that the absurdity of classifying overhead wires for traction purposes as dangerous was sufficiently obvious to prevent both the stupid action of the protesting property owners and the still more stupid newspaper comment that we have quoted. Overhead electric railway wires are, perhaps, unsightly (although with good construction they may be made ornamental), but they are certainly not dangerous in the usual sense of the word. Ignorant prejudice is to be blamed for the protest, and it seems curious that travelers should wish to deny themselves the many advantages offered by electric traction on such an untenable ground.

### A St. Louis Power Station.

The illustration on this page shows an interior view of part of the power station of the Union Depot Railway Company, of St. Louis. The station is equipped with twenty-four 80 horse-power Thomson-Houston railway generators with the requisite steam engine capacity. The company has been in operation since the first part of last July and has been compelled to enlarge its plant on several occasions. The company now operates 60 motor cars on the Thomson-Houston single trolley overhead system. Mr. Theo. P. Bailey, of the last named company, secured the contract for the equipment of this road.

### Electric Railways in Topeka.

The Topeka, Kansas, Rapid Transit Company is now operating seven lines of electric cars over 18 miles of track. The company operates 30 motor cars, each equipped with two 10 horse-power motors, and 20 trail cars. The regular daily service requires about 30 cars. The power station is equipped with seven Thomson-Houston generators of 60,000 watts capacity each, the armatures making 900 revolutions per minute. About 6.8 tons of slack coal per car day of 18 hours is used under the boilers. The car mileage per day is about 2,275. The adoption of electricity has effected an increase of 16 per cent. in the business of the company.




THE ELECTRIC POWER STATION OF THE UNION DEPOT RAILWAY COMPANY, ST. LOUIS.

A congress is to be held in connection with the electrical exhibition to be opened next Spring at Frankfort-on-the-Main, and Herr Werner Siemens will be asked to occupy the presidential chair. Herr Von Stephan, of Berlin, has accepted the chairmanship of the organizing committee of the exhibition.

### London Board of Trade Regulations for Electric Supply Companies.

The Board of Trade, London, has issued a set of regulations and conditions for securing the safety of the public, and for insuring a proper and sufficient supply of electric energy to the consumers situated in the district under the control of the Metropolitan Electric Supply Company. These regulations, says *Engineering*, appear to be chiefly compiled from the codes already issued governing the erection of underground and aerial wires, and provide very fully for the safety of the public. They recognize three kinds of supply: (1) Low pressure, at or below 300 volts for continuous currents and the equivalent of 150 volts for alternating currents; (2) high pressure, not exceeding 3,000 volts, or the equivalent of 3,000 volts, whether continuous or alternating; (3) extra high pressure, exceeding 3,000 volts. By the expression "the equivalent of 150 volts," applied to an alternating supply, is meant the pressure that will produce the same heating effect on a thin stretched wire as will be produced with a continuous supply under a pressure of 150 volts. In general the pressure is measured between any two conductors through which the supply is given, or between any part of either conductor and the earth. In the case of conductors laid in conduits, and classed as low pressure, there must not be a difference between any conductor and earth of more than 300 volts, or 150 volts, if alternating, or between any two conductors of more than 500 volts, or 250 volts, if alternating. In general, consumers are to have a low pressure supply only, but on the joint application of the consumer and the undertaker, the Board of Trade may permit of a high pressure supply for special purposes. The extra high pressure supply can only be given to premises in the sole occupation of the undertakers, and then only with the written consent of the Board of Trade.

Great pains are to be taken to insure safety with the high pressure supply. Conductors placed above the surface of the ground, other than aerial conductors, are to be completely inclosed in brickwork, masonry, concrete or metal, the latter being connected to earth. Where high pressure mains are laid in subways, or in the same conduits with low pressure conductors, they are to be inclosed in strong metal casing connected to earth. In all cases ample provision is to be made for the immediate escape to earth of all leakage from high pressure mains, and it is not to be allowed to charge the surface of the ground, or to pass into adjacent low pressure mains. These mains are not to be naked; they must be continuously insulated, and must show a resistance of 100,000 ohms per mile for every volt of pressure of supply. Over the entire circuit, including all devices for producing, consuming, or measuring energy, connected to such circuit, the insulation resistance shall be such that should any part of the circuit be put to earth through a resistance of 2,000 ohms, the leakage current shall not exceed 0.04 ampere in the case of continuous currents, or 0.02 ampere in the case of alternating currents. Transformers situated on consumers' premises are to be completely inclosed in walls or metal casing connected to earth, and devices are to be provided for preventing the low pressure wires being charged to high pressure by leakage.

Except in respect of the last of these provisions, the safety of the public has been considered most fully, and the convenience of the Metropolitan Electric Supply Company made to bow to it. That company is supplying alternate currents from most of its stations, and, therefore, the bulk of its work is being done under the more stringent part of these rules. Although compiled in the first instance by the Board of Trade, they were submitted to a committee of the Institution of Electrical Engineers, among which it is quite evident that the transformer system had few friends. As regards the last requirement, that consumers' wires fed on the transformer system are to be provided with devices for preventing them being charged from the high pressure wires, the safety of the consumer seems to have been lost sight of in the dread that is entertained in some quarters of an outbreak of fire resulting from earth contacts. The simplest method of avoiding this contingency would be to put the secondary circuit of the transformer to earth. Then if any leakage took place it would burn down the fuse and sever the connection instantly. But this arrangement is not allowed, and in place of it there must be used a very delicate instrument which makes contact with earth when charged to a certain potential. No doubt the connection of every subscribers' circuit to earth would lower the insulation resistance of the entire circuit very sensibly, but it is possible to attach too much importance to this point. The safety of householders and their families who are obliged to touch the lamp fittings daily is better worth considering than that of the undertakers' employés, who are perfectly cognizant of the risks they run and of the means to meet them. A device which allows the wires to be charged to a high potential before it comes into operation is not what one would desire in a house.

Aerial conductors are to be kept at least 20 feet from the ground; at street crossings the height must be 35 feet, and no part of a building or erection, other than a support for the conductor, is to be approached within 7 feet, except when entered for the purpose of supply. The distance between the supports is not to exceed 200 feet; when the direction is changed they are to be within 150 feet of each other. In crossing a street the conductor is not to make an angle of less than 60 degrees with it. Precautions are to be taken against broken wires falling upon telegraph and telephone conductors. In addition, the electric light wires are to be continuously insulated with approved material of not less than $\frac{1}{10}$ inch of thickness. In cases where the extreme difference of potential in the circuit exceeds 2,000 volts, the thickness of insulation is not to be less, in inches or parts of an inch, than the number expressed by dividing the number of volts by 20,000. The insulation has to be further protected against abrasion. Such conductors are not to be allowed to carry their own weight in the spans, but are to be carried from suspending wires by non-metallic ligaments. The suspending wires are to be attached to the supports by insulators of high quality. As soon as an aerial conductor is permanently put out of use, it must be taken down. Default regarding any provisions relating to safety render the undertakers liable to a penalty not exceeding £10, and to a daily penalty not exceeding £10.

These rules concerning aerial conductors seem to have been designed with a view of preventing their use. That is not a matter that will cause much regret to dwellers in the district of the Metropolitan Electric Supply Company. In country places, however, where the same stringent conditions are enforced, the cost of erecting wires that will satisfy the Board of Trade is often prohibitory. The demand for a tenth of an inch insulation for 2,000 volts is likely to defeat itself, seeing that the best quality of vulcanized rubber is usually applied in a layer of only about half this thickness. The certain result is that an inferior porous covering will be used that will afford less security. We suppose that the depth of the covering has been fixed in some relation to the sparking distance in air, but it is difficult to see what connection there is between the two.

Before supplying energy through any feeding, charging or distributing main, the undertakers must give a week's notice to the County Council and the local authority. After the supply has been commenced it must be maintained constantly at the standard pressure and equal to the demands of all consumers. Variations from the standard pressure, not exceeding 3 per cent. in a low pressure supply and 2 per cent. in a high pressure supply, will be permitted, so long as they do not recur so frequently as to cause unsteadiness in the supply. These limits of variation apply to the mains; at the consumers' terminals 4 per cent. variation is permissible. Stoppages of supply can be made for one hour for purposes of testing; for longer stoppages notice must be given. Default in obeying the regulations renders the undertakers liable to the penalty of £5, and to a daily penalty of £5.

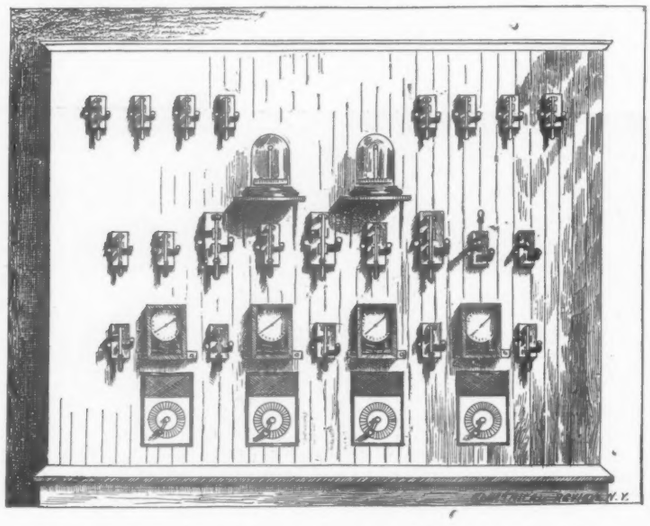


FIG. 1.—ELECTRIC LIGHT SWITCHBOARD IN THE NEW PULITZER BUILDING, PARK ROW, NEW YORK.

### Electric Roads for Brooklyn.

The State Railroad Commission on November 18, approved the application of the Brooklyn City Railroad for permission to change its motive power from horse and steam power to the electric single trolley wire system on its Third avenue road, from the Brooklyn city line to Fort Hamilton, and also to use electric motive power on a road about to be built by the Brooklyn City Railroad Company on the following route: Commencing at the intersection of Third avenue and Sixty-fifth street in New Utrecht, thence along Sixty-fifth street to and along Second avenue to the boundary line between Brooklyn and New Utrecht, and also from the point where Third avenue intersects Bay Ridge avenue in New Utrecht, along Bay Ridge avenue to and along Thirteenth avenue, Eighty-sixth street and Twenty-fifth avenue to the property of the Brooklyn City Railroad, situated on Gravesend Bay, at the foot of Twenty-fifth avenue. The total length of the intended extension will be about five miles. The usual conditions regarding the erection of poles, the rate of speed and insulation, and repair of wires were imposed.

A number of citizens have signed a petition protesting against the adoption of the overhead system. The petition is being taken from house to house along the proposed electric line, and additional signatures are being solicited.

### A Compliment to a Brave Young Telephonist.

Photographs of the wreck caused by the collision of the two finest vestibuled trains belonging to the New York Central Railroad on the night of September 8th, have been forwarded to Mr. Charles B. Doolittle, in San Francisco, a Bridgeport young man, by his Boston friends and inscribed to "The Hero of the Occasion," says the Bridgeport *Standard*. Young Doolittle, who was on his way to San Francisco to take a position with the Pacific Telegraph and Telephone Company, distinguished himself by rescuing the engineer who was crushed between the wreck of his cab with both legs broken and enveloped in a cloud of escaping steam. The prompt action and cool bravery of the young man was warmly commended by the train men and passengers. Among the latter was a large party of telephone officers *en route* to the Detroit meeting of the National Telephone Exchange Association.

### Bids For Lighting New York.

Mayor Grant, Controller Myers and Public Works Commissioner Gilroy, as members of the Gas Commission, met last week and approved of the form of contract prepared by Secretary McCormick, to be submitted, through public competition, to the different electric lighting companies who are willing to illuminate the 1,386 electric lamps in the streets and parks of the city.

Proposals covering the entire year 1891 must be forwarded to Secretary McCormick prior to Dec. 4th, 1890. The Board of Estimate and Apportionment has gone upon record as being opposed to higher rates than in former years, and it also threatens to return to the use of gas should too high figures be demanded by the electric light companies.

In his departmental estimate, Commissioner Gilroy asks for $826,000 under the appropriation entitled "Lamps, Gas and Electric Lighting." The appropriation in 1889 was $700,000, and the increase, Commissioner Gilroy explained, was caused by the firm attitude of the electric light companies in asking for more money, on the ground that their expenses were greater than ever, because of the enormous rentals charged by the Subway Company. The Board of Estimates threw out the item of $126,000 additional asked for by the Commissioner, and resolved to make a new departure by separating the appropriation for gas and electricity and giving a fixed sum to each. Last year the allowance for electric lighting was $75,000.

### Westinghouse Business.

The Westinghouse Electric and Manufacturing Company, Pittsburgh, have made the following shipments thus far in the present month: 40 alternating current incandescent dynamos, aggregating a total capacity of 30,000 sixteen candle-power lamps, 1,200 alternate current meters and a large number of converters. To handle the increase of business which each succeeding month brings, the Westinghouse Company has been obliged to considerably augment its Pittsburgh shipping facilities.

The demand for alternate current meters has been particularly pressing, and the department devoted to the manufacture of these instruments has been taxed to the limit of its capacity. The same is true of the Westinghouse converters, which are in great favor on account of their high efficiency. It is said that during the entire time they have been manufactured not a single converter has been returned on account of faulty construction or inefficiency.

Good reports of the behavior of the Lansing, Mich., Electric Railway continue to be received. The Westinghouse Company, it will be remembered, installed this road about two months ago; since then 12 other roads have been completed and about 50 more are in process of construction.

The motor department at the Pittsburgh shops has recently been extended, which now gives the company the capacity to build and ship 100 motors per month.

### Telephone Company Wins.

In the case of the Hudson River Telephone Company *vs.* the Watervliet Turnpike and Railroad Company, the defendant recently moved for an extra allowance of $2,000 before Justice Fursman, of Albany, N. Y., on the decision rendered in the defendant's favor, the same to be taxed with the costs in the action. The motion was based on the ground of the expense incurred in the employment of foreign counsel and witnesses, and the intricate character of the questions involved. The motion was opposed by the plaintiff, and on November 18 a decision was handed down by Justice Fursman denying the application on the sole ground that the action being to restrain the defendant from employing a particular system only, and over a part only of its road, the franchise was not involved, and there is, therefore, no basis on which an allowance can be estimated. In one of the affidavits used on the motion is a statement of the earnings of the road from July 21 to August 13 and August 14 to September 6, 24 days each. For the first period they footed up $8,130.19, and for the last, $9,857.91.

A firm of Rochester, N. Y., brokers have published a circular announcing an issue of $3,000,000 in 40-year consolidated mortgage five per cent. gold bonds upon the property of the Rochester Railway Company. The bonds are dated April 1, 1890, and will fall due April 30, 1930. The interest is payable April 1st and October 1st at the office of the Solicitors' Loan and Trust Company, Philadelphia, which is also trustee under the mortgage. Of the bonds, $1,000,000 will be reserved in the treasury to retire at maturity the $875,000 bonds which existed when the road was purchased.

### The Electric Light Plant in the New Pulitzer Building.

The new building on Park Row, in this city, known as the Pulitzer building, is to be splendidly equipped with electric lights. A good idea of the plant may be obtained from the illustration on this page. The switchboard is shown in Fig. 1, opposite.

The dynamo room is in the basement, at the front of the building. It is cool and well ventilated, with nicely finished walls and a concrete floor. The equipment, which is admirably arranged, consists of four compound wound United States dynamos, each with a capacity of 800 lights, two 100 horse-power New York Safety engines and two Watts-Campbell Corliss engines of greater horse-power. These latter engines, besides running two of the dynamos, will run a large printing press.

Each dynamo is fitted with a compensating switch let into the mains between the machine and the switchboard. The mains are carried from the machines to the switchboard in a brick conduit, asphalted on the inside, and set into the floor, so that the covering plates come flush with the floor surface. This is thought to be the first plant in which a conduit is utilized for this purpose. The idea was adopted as affording the best and most convenient means of getting at the mains in a case of emergency. The appearance of the plant is much improved by having the mains out of sight.

The switchboard is of handsome hard wood and the instruments and switches are well placed on it. The circuits for each floor of the building are controlled directly from the switchboard. Besides the lighting circuits there are a 30 horse-power motor circuit and a five horse-power motor circuit. The building is wired for 4,000 lights, all the circuits being carried in the tubes of the Interior Conduit and Insulation Company, of this city, except where wires are run along risers; in such places poplar moulding is used.

A 6,000 candle-power Thomson-Houston focusing lamp will be employed for photo-lithographic work. Current for this lamp and for five 2,000 candle-power arc lamps to be placed on the tower of the building, will be supplied from the incandescent circuits.

The electrical equipment of this great building is in keeping with the rest of the appliances and devices for the comfort and convenience of the municipality of tenants which will occupy the building.

### Some More of Our Navy Launched.

Our largest war vessel, the "Maine," was launched from the Brooklyn Navy Yard on November 18. She will be, when completed, fit to fight with almost any of the European war vessels, and will be our star war ship.

She will be lighted by electricity, the plant consisting of four dynamos and engines, so connected that any one of them is able to supply all the circuits for the incandescent lamps. Three powerful search-lights, for tracing torpedo vessels, rams or other vessels of an enemy, or to find hostile submarine torpedoes, and for navigating tortuous and dark channels, are also to be installed. The dynamos will supply current for internal illumination, side lights, headlights and lights in the magazines and bunkers. She is fitted with a range finder and other electrical appliances for working the guns, as devised by Lieutenant Bradley A. Fiske.

### As to Registering by Telephone.

A novel point was discussed on Thursday: "Can a voter register by telephone?" The law says a person must apply in person at the office of the city clerk to register, and unless he is registered he is not entitled to vote in the city election. The question hinges on whether an application to register through the telephone is legal.

On Thursday Jailer Birdsong, who is at present kept close to business by reason of having a large number of prisoners in the jail, rang up the city clerk, and asked to be registered. The clerk was familiar with the jailer's voice, and could have sworn that the voice was that of Nat Birdsong. He knew more, and that was that the jailer had paid his taxes, and was clearly entitled to register; and, furthermore, it was an application in person; but there was a doubt in the clerk's mind as to the difference between an application in person in his office and an application in person several blocks away and over a wire.—*Macon, Ga., Telegraph.*

### The Illuminated Walking Stick.

The newest walking stick for men is one that bears the somewhat suggestive title of the "club man's stick." It has a round head and looks like anybody else's cane, but its peculiarity appears when its head is unscrewed, as it can be, disclosing a tiny electric light in a glass bulb. The fitness of the title appears at once, says the *Evening Sun*. No more sleight-of-hand performance with the keyhole when the busy club man gets home late and tired. No more unhappy and disturbing stumbling through dark halls and into unlighted apartments. When the kindly office of the stick as an aid to walking has been fulfilled, the stick literally becomes a light unto his feet and a lamp unto his path.

### Took the Business from Him.

F. A. Bates and A. C. Bates employed Joseph B. Lang to organize the Anglo-American Storage Battery Company, of Illinois. He claims they took the business away from him in violation of contract and gave it to Frank Collier. He is suing the Bateses for $2,500 for services. Last week his attorney asked Judge Baker, of Chicago, to issue an order garnisheeing what property belonging to the defendants might be found in the Anglo-American Company's hands. The order has been entered.

**Seattle, Wash.**—Standard Electric Company; capital, $25,000.

**Newark, N. J.** — The Newark Electric Power Company; capital, $150,000.

**Greenville, Ill.**—Greenville Electric Light & Power Company; capital, $10,000.

**Denver, Col.**—The Canon City Electric Light and Power Company; capital, $30,000. The directors are J. H. Peabody, W. T. Birdwell, C. G. Nikirk and H. B. Slater.

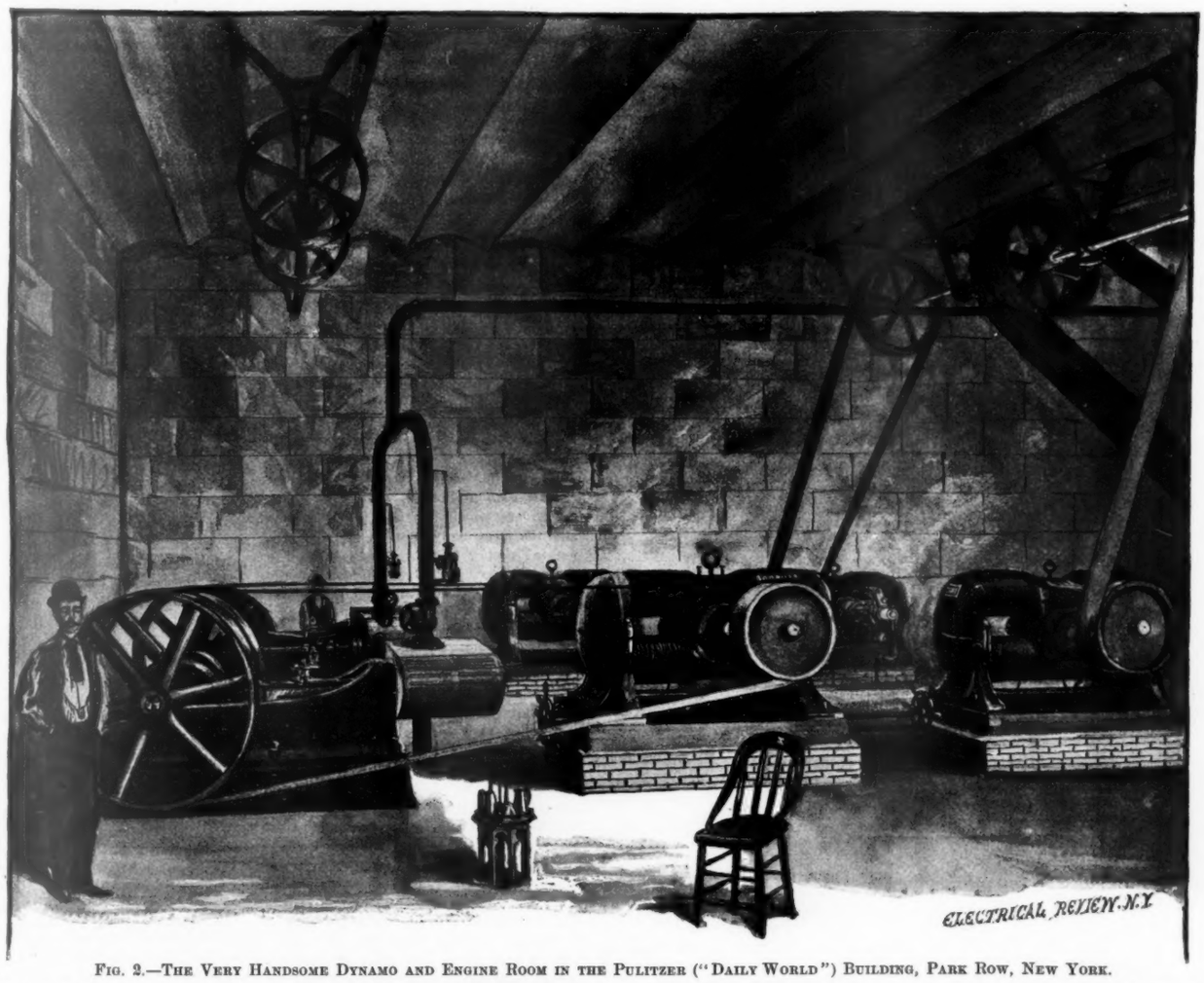



FIG. 2.—THE VERY HANDSOME DYNAMO AND ENGINE ROOM IN THE PULITZER ("DAILY WORLD") BUILDING, PARK ROW, NEW YORK.

**Cleveland, O.**—The Brush Electric Company; increase of capital stock from $2,000,000 to $2,500,000.

**Portland, Me.**—The Roberts Storage Battery Company; capital, $1,500,000. Incorporators, W. Farwell, Sherbrooke, Que.; J. W. Simonds, Portland, Me.

**Jamestown, N. Y.**—The Citizens' Railway Company, to build an electric railway; capital, $200,000. Directors: Philip C. Templeton, William Hjorth, J. Cowles, J. B. Fisher, F. P. Cardellos, C. B. Shaffer and I. W. Newcomer.

**Grand Island, Neb.**—Grand Island Light and Fuel Company have filed an amended charter increasing the capital stock to $300,000. The incorporators are Chas. A. Wiebe, Geo. D. Hetzel, Chas. Wasmer, Heyward G. Leavitt and W. P. King.

**Quincy, Mass.**—The Quincy and Boston Street Railway stockholders have voted to double the capital stock, making it now $100,000.

**Chicago, Ill.**—The McFell Electric Company; capital, $8,000. Incorporators, Judson McFell, Frank W. Watts and William J. McWade.

**Butte City, Mont.**—Independent District Telegraph Company; capital, $25,000. Incorporators, Harry L. Haupt, Robert D. Ecker and O. M. Best.

**Chicago, Ill.**—Fuller Watchman's Electrical Detector Company; capital, $200,000. Incorporators, Isham D. Fuller, William D. Carlisle and E. S. Bottum.

**Somerville, N. Y.**—Somerville and Raritan Electric Light Company; increase of capital stock to $50,000. J. W. Ballentine, president; J. L. Griggs, treasurer, and J. P. Major, secretary.

**Chicago, Ill.**—Morgan Gardner Electric Company, to manufacture and sell electric mining machinery, etc.; capital, $100,000. Incorporators, Henry S. Gardner, James P. Gardner and George C. Gardner.

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No attention will be paid to communications for the REVIEW without the *name and address of the writer.*

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Both the theoretical and practical electrician ought to be pleased with this issue of the ELECTRICAL REVIEW.

The Indian outbreak in the West has already made it necessary to hastily construct several military telegraph lines.

By an amendment to the constitution of the Electric Club, of this city, offered at the meeting of November 20th, it is proposed to admit a new class of members—namely, associate members. Any person elected to Club membership as an associate will be required to pay an initiation fee of $10 and annual dues of $12. An associate membership carries with it the privileges of the Club and the Club house, except those of voting and holding office. The object of the proposed amendment is to give to students of electricity and others interested in electrical progress, who do not wish to pay the regular Club dues for resident members, an opportunity of enjoying the papers read and discussions held before the Club, and the advantages of the Club library. We heartily commend the idea, and hope that it will be adopted either in this or other form. Final action, we understand, will be taken at the next regular meeting, to be held on the third Thursday in December.

The suit of the electric light companies of New York against the Subway Company, on the question of exorbitant charges, is now before the court, and a decision is expected next week.

Our highly esteemed contemporary, *Harper's Weekly*, "a journal of civilization," appeared last week with its front page given up to a soap advertisement! As cleanliness is next to godliness, must we conclude that here is where we may look for the civilizing influence?

The members of the Electric Club have listened to many interesting lectures, but seldom to one more fascinating and luminescent than that which was delivered by Professor Nichols Thursday evening, Nov. 20th. The lecture is reproduced in full in another part of this issue, but we wish to draw special attention to Professor Nichols' remarks on the efficiency of the fire-fly. A short time ago we made a note on the researches of Professor Langley on this subject, to which reference is made by the lecturer, and pointed out the great advance accomplished in the study of this most wonderful of the many sources of light provided by nature by the measurement of its efficiency. Now that matters have gone so far, it is to be hoped that physicists will not rest until they discover the mysterious insect's secret, and learn to produce light without heat.

The opening of the new underground railway in London marks an important epoch in the development of electric traction. Electric railway engineers in this country have their hands full to overflowing with work in connection with abolishing the horse from surface railways; but, as we well know, they cast occasional sidelong glances at the roads at present operated by steam, and confidently expect to get amongst them before very long and show what the electric motor really can do to ameliorate the conditions of long and heavy travel. The new electric road in London is short, it is true, but the travel will certainly be very heavy, and the electric locomotives are of a type nothing similar to which has been tried in this country. It is a distinct advance in electric traction, and the operation of the road will be watched with interest by electrical men on both sides of the water.

### *AT IT AGAIN.*

Newspaper science shone forth brilliantly once more in the columns of the metropolitan dailies one day last week. In what purported to be a telegram from Liverpool, the conspicuous announcement was made that a dynamo pipe (*sic*) had burst on board the steamship "City of New York," and that a number of passengers had been almost asphyxiated by the fumes of ammonia, arising, presumably, from the damaged dynamo. Exactly what a "dynamo pipe" was must have puzzled a good many newspaper readers, because probably five out of ten have at least seen a dynamo nowadays, and why it should have given out fumes of ammonia when burst must have puzzled them still more.

However, the correction followed the canard very closely, although very few papers took the trouble to print it. The true story was that part of the refrigerating machinery got out of order, and there was a slight escape of ammonia gas, causing some inconvenience between decks, but nothing more. The incident is absurd but nevertheless instructive, as it indicates very clearly what we have frequently pointed out of late, viz., that the newspapers betray a startling eagerness to connect every accident—or even incident, for the case in point was nothing more—for which a satisfactory explanation is not forthcoming at once, with electricity. As the public is only too ready to believe that electricity is capable of anything, this sort of thing passes current together with a great deal more of the same order as regards accuracy and veracity.

The general interest in matters electrical is increasing and widening so rapidly, however, that newspaper writers and editors will soon have to change their tactics and devote as much care and method to the preparation of scientific news as they do to that relating to sport and the drama.

### *THE OHIO STATE TRAMWAY ASSOCIATION.*

NINTH ANNUAL MEETING HELD AT COLUMBUS, OHIO.—WHAT WAS SAID AND DONE.

The ninth annual meeting of the Ohio State Tramway Association was held in the Hayden Bank Block, Columbus, Ohio, November 19th, 1890. The meeting was called to order at ten o'clock by Hon. John N. Stewart, vice-president, of Ashtabula, Hon. Wm. B. Hayden, president, being absent. Chairman Stewart stated that in the absence of Secretary Lang, of Toledo, Treasurer J. B. Hanna, of Cleveland, would act as secretary in his stead.

The delegates present, and companies represented by them, were as follows:

Akron—Akron Street Railway Co., W. D. Chapman, president, and J. E. Metlin, superintendent.

Ashtabula—Ashtabula Street Railroad Co., John N. Stewart, president.

Cleveland—East Cleveland Street Railroad Co., Dr. A. Everett, president; B. Blee, general manager. Woodland Avenue and West Side Street Railroad Co., J. B. Hanna, secretary.

Columbus—Columbus Consolidated Street Railroad Co., A. D. Rogers, president; R. E. Sheldon, vice-president; E. K. Stewart; secretary and treasurer. Glenwood & Green Lawn Street Railroad Co., R. R. Rickley, vice-president.

Dayton—C. J. Ferdening, president, and G. W. Rodgers, vice-president, Dayton Street Railroad Co. C. B. Clegg, president, Oakwood Street Railroad Co.

The following gentlemen, representing business interests, were present as visitors:

R. M. Johnson, of the Northern Car Company, Minneapolis, Minn.; C. C. Curtis, Short Electric Railway Company, Cleveland, Ohio; Ernest L. Clark, secretary Illinois Electric Material Company, Chicago, Ill.; A. H. England, secretary and treasurer Electric Merchandise Company, Chicago, Ill.; S. J. Collins, of the Meaker Manufacturing Company; H. F. Probert, Sheffield Velocipede Company, Three Rivers, Mich.; C. A. Benton, of the Rae Electric Railway System; John I. Beggs, district manager, Alexander H. Lewis, special agent, and William Hand, railway department, Edison General Electric Company, Chicago, Ill.; C. K. Harding, president the Harding Electric Railway Company, Atlantic, Iowa; A. W. Brickwood, president the Russell Street Carette Company, Chicago, Ill.; W. J. Cooke, vice-president McGuire Manufacturing Company, electric cable and elevated railroad trucks, Chicago, Ill.; F. B. Brownell, Brownell Car Company, St. Louis, Mo.; W. S. Wills, of Wills Elastic Wheel Company, Charlottesville, Va.

The meeting was called to order at 2.30 o'clock by Chairman Stewart, who said: I do not know of anything that would interest us any more at this time than to hear from some of the visiting attaches of the street railway interests. I now have the pleasure of introducing to you Mr. Charles K. Harding, president of the Harding Electric Railway Company, Atlantic, Iowa.

Mr. Charles K. Harding said:

Heretofore the word "conduit" has been almost inseparably connected with some slotted arrangement and failure, for it should be understood to preserve insulation you must exclude water, and to do that the conduit must be entirely closed, without slot or other opening through which the current is taken. In order to accomplish this result, I employ a tubular iron casing, in the top of which is a channel or flanged portion in which is insulated and supported the sections of working conductor. These sections may be from four to six feet long and extend an eighth of an inch or more above the surface and are normally insulated from each other, the casing and the main conductor which extends through the lower tubular part and is entirely surrounded and embedded in insulating material.

In the end of each section of the casing or conduit, there is an enlargement of the lower tube which forms a junction box in which is located a small electro-magnetic contact-making device, which, when operated, connects its conductor section with the main or supply conductor. One end of the winding on the magnets of these contact devices is connected through a simple switch to the adjacent working conductor section, and the other end directly to the conductor section

on the other side by means of this arrangement and a second brush on the car. I employ a very small portion of the current to automatically operate the contact device and bring the exposed sections of working conductor separately and successively into connection with the main insulated supply conductor, when these sections are immediately under the car and protected by it.

In other words, I get the current to the car through the series of insulated exposed sections, which are fed from the main conductor as the car passes along, and are at all other times completely insulated from the wire carrying the current. By the employment of a derived circuit in multiple arc with the motor circuit, I am enabled to use a very small portion of the main current for the operation of the contact devices, and to make the magnets of small size and wind them with iron wire, thus making the construction of the contact-making devices a comparatively simple matter, and enabling them to be placed in a small closed cavity in the end of the sections, where they will be readily accessible, and are adapted to be interchangeable.

It will be readily seen that the short exposed sections of working conductor will have very high insulation, and prevent all but the most inappreciable amount of leakage, when it is taken into consideration that under no possible combination of circumstances can any section except those immediately under the car be brought into or maintained in connection with the supplying current.

Chairman Stewart: Mr. Curtis, of Cleveland, representing the Short electric railway system, I see, is present. Have you anything to offer?

Mr. Curtis: I do not know that I can say anything to the Convention regarding the Short system, with which you are not already perfectly familiar. The largest contract ever let in this country by disinterested parties was given by a syndicate of Philadelphia gentlemen for equipping the street railway system of Rochester, New York, to our company. That, as you probably know as well as I, was given after a very thorough and careful investigation by experts who came to our factory, went through the works, visited our system working in different places and make their report. On the basis of that report the purchase was made for Rochester.

Now, that which has heretofore been, I believe, the curse of electrical railroading in its practical operation, was the one item of repair. In one town, I am told by gentlemen connected with the road, the repairs last year amounted to as high as $1,100 per car. When I went into the Short company they had a road running in Muskegon, Michigan, equipped with their system. That road had been running for six months, commencing with five cars, and at the end of the six months having nine cars in operation, and the total repairs on that road have not exceeded $100 on all the electrical equipment. I heard remarks in the Convention of consolidations. If there has been any consolidation of the Short Electric Railway, or any other railway, it has occurred since I left home this morning at seven o'clock. I do not, of course, know where the rumors may have started, but there is no foundation for them, in fact.

Chairman Stewart: We have with us a gentleman representing the Rae system, I refer to Mr. C. A. Benton, of Detroit, Michigan, who will now take pleasure in addressing you.

Mr. C. A. Benton said: Gentlemen of the Convention, I represent the only single motor that I believe is in successful operation. The peculiar feature of our motor over that of other systems is, that it is geared to both axles, a construction which permits the use of large wearing parts, slow speed of armature shaft, and, therefore, reduced friction and long life; it secures perfect insulation between the motor and the truck, eliminating all electrical strain and making burn-outs from this cause impossible.

We have 21 cars running at Saginaw, Michigan, which have been run for 11 months and the repairs on the entire equipment have not reached the sum of $50, and the man who went there to do the winding in case of a break had nothing to do, and they finally bought him a uniform and have been using him as an extra conductor on the line. This is absolutely true, and if you don't believe it, you can go there and see it.

The Detroit Electrical Works are in this position: They are sound financially, their guarantees are good, they are prepared to send a truck motor to any responsible street car line having any system, and put a car upon it and leave it for them to use.

Mr. Clegg: What is the weight of your motor as compared with others?

Mr. Benton: It varies very little from the Sprague or the Short. I think it is a little lighter than the Thomson-Houston.

Mr. Clegg: It struck me that it was much lighter.

Mr. Benton: There is but very little difference. The weight, of course, would vary some for this reason; that we weigh them on the trucks, and sometimes we have heavy wheels on the truck and sometimes not so heavy.

Mr. F. B. Brownell, of the Brownell & Wight Car Company, then spoke at some length about the construction of electric cars.

He said in part: I have thought also that the motors, instead of being horizontal and close to the ground, should be located vertically and so arranged that every part could be easily gotten out for repairs or removals or renewals, or whatever might be necessary to do with them, and the whole system of construction changed to something that is practical and desirable, which I do not think the present mode is.

These subjects I think are worthy of some thought, and I think if the railroad companies and the motor people will work in harmony on that line, and especially so far as the location of the motors is concerned, they will find that many of the troubles of the street car companies and the electric companies will be removed, and that a large portion of the money that is now used to pay the cost of repairs can be utilized as dividends, which, I am sure, will suit you all very much better.

Mr. Johnson, representing the Northern Car Company, of Minneapolis, spoke at some length of his company.

Chairman Stewart: While the street car people of Ohio were looking around to find a substitute for the mule and the horse, a gentleman who is a pioneer in the adoption of the overhead system, and who is now with us, saw fit to investigate that system and largely adopt it upon his lines in Cleveland. I now have the pleasure of introducing Dr. A. Everett, of the East Cleveland Street Railway Company.

Dr. Everett: All I have to say to you is to come and see me. We will show you the Edison system in practical operation, the Sprague system, the Short system, the Westinghouse system, the Rae system, and very soon, within two weeks, we will show you another system from Baltimore.

Mr. W. J. Cook, vice-president of the McGuire Manufacturing Company: When electricity was first introduced, we had a truck which we thought was peculiarly adapted for electricity. I found out from the electric people that they had designed that the standard should be 30 horse-power. I figured from 30 horse-power up to a truck, following the suggestions of the electrical people largely. When I had completed my truck, my electrical friends said I was wild, simply crazy; that I had 1,500 pounds more than I should have. I insisted that my figures were right. The result was I did not sell any trucks for electric motors for six months; they thought I had too much strain. In the last year, however, I could not make trucks enough; I am making them heavier than ever and do not think that they are heavy enough. They have been figuring the standard on the other side from the basis of a two-horse team and came down, while I started from 30 horse-power and went up. We are not quite reconciled yet.

We have, very recently, at a very great expense, gotten up a frame made of pressed steel, the entire frame consisting of only four pieces. Noise has been a disagreeable feature to some extent in the electric motor; some motors are very noisy and some trucks are very noisy. We have gone to work and made a truck of very few pieces, less than half the number I believe used in any other truck constructed to-day.

Mr. Clegg: What will be the wheel base?

Mr. Cooke: Four feet six inches on the long car; just enough to let the motor in. The electrical people wanted us to make it longer, but we are trying to get the wheel base as near the guage of the car as possible.

Secretary Hanna: Mr. Cooke, can you tell the gentlemen present anything about the new electric heater we were talking of this morning?

Mr. Cooke: The gentleman representing the heater expected to be here. He is an old school friend of mine, and that accounts for the interest I take in it. It was invented in Minneapolis. I have one in my house in the laundry. I take off the burner in the house and connect the wire, and my laundress irons all day by means of the heater. The iron only gets so hot; it can't get any hotter, and it holds that heat a long while.

He has arranged a heater for a street car. I am sorry he is not here to explain it himself. It is merely a ribbon that runs along under the edge of the seat, I think, about six or eight inches wide, and possibly a half or three-quarters of an inch thick, and with the current from the trolley he heats the car perfectly to any degree of heat that is necessary. There is a button attachment at the motor man's command, so that he can give the car quarter heat, half heat, three-quarters heat or full heat, just as the demands of the weather may require.

Mr. C. B. Fairchild, associate editor of the *Street Railway Journal*, New York, then addressed the Convention, as follows: I am very glad to have the opportunity of looking you in the face and making myself known to you at this time. The hour is too late for me to enter into much of a discussion. I would like, however, in the first place, to disabuse your mind of one thing. The street railway men sometimes seem to think that the technical press are very much on a par with the reporters of the daily press and sometimes you have been afraid to let us into your meetings and afraid to talk before us as you would among yourselves. Now, we wish very much that you would regard the technical press—at least, I am speaking for the paper that I represent—not as a newspaper watching you, to pick flaws in your work and criticise you unfavorably, but that we are working virtually in the interests of the street railway companies, and that we are one with you. You have probably noticed that we have urged that more attention be given to these conventions. It seems to me that you do not fully appreciate what a power you might be in this State if all the street railway people were sensible of the fact that they should be present at these meetings, or, at least, send in some paper, and take hold of this matter and push this Convention to a successful existence, so that it can be made to wield this power it should wield in the municipal affairs of the State. We hear a great deal of complaint, Mr. President, about unfair legislation, both from State and municipal authorities. I believe that if there is any more unjust or unfavorable legislation, by which the street railway men suffer, that they themselves are to blame for it.

Chairman Stewart then asked if Mr. Beggs or Mr. Lewis, representing the Edison General Electric Company, were present, and desired to be heard.

Mr. William Hand responded to the call of the Chair and stated, that, to his regret, neither Mr. Beggs nor Mr. Lewis were present, but, that, as he was working in the interest of the Edison General Electric Company, as an electrical expert, he would like to state that he, for the Edison Company, had just completed the installation of the Glenwood & Green Lawn Street Railway, of Columbus, Ohio, extending about four miles west from High street, with five cars, with the Edison System. The road has been in operation over two months and the repairs on the cars during that time have not amounted to one dollar. There has not been an armature taken out of any of the cars.

Chairman Stewart: I will say to Mr. Hand that quite a number of the delegates had the pleasure of riding over his road, and that if the revenues are to-day about twice what they were yesterday, just give the street railway journals the credit for it, because they put the money in the slot. I wish to say that the next meeting of our association will be held on the second Wednesday in November, 1891, at Akron. I have no doubt but that every street railroad man in the State of Ohio will be present. Just at this time there is so much going on in every city and village, almost, towards improving the systems and changing the systems that they have had in use from horses to electric or cable, that it seemed to be necessary for the street railway people to attend to their business at home instead of coming to this Convention, although we were in receipt of a communication from almost every road in the State of Ohio that some of their representatives would be here. Litigation of an important character in Toledo has called a number there; trouble in Cleveland is keeping a number there, and so on all through the State. There is no doubt whatever but what the Akron meeting will be a very interesting one, for the reason that there will be papers prepared upon all of the subjects that will be of interest to the fraternity in the State as well as to the fraternity at large, and I hope that all who can find it agreeable will be at Akron, and I feel safe in saying that every road in the State of Ohio will be represented at Akron by one or more delegates.

Adjourned to meet at Akron, Ohio, on the second Wednesday of November, 1891.

### CONVENTION NOTES.

D. F. Morris, the Chicago representative of Milliken Brothers, was on the ground, and displayed a neat minature sample of the celebrated Milliken iron poles for street railways.

The Chicago delegation, which left on Tuesday night by special cars, was composed of the following gentlemen: L. S. K. Monroe, E. V. Cavell, P. A. Andrews, John N. Reynolds, J. B. O'Hara, D. B. Dean, of the ELECTRICAL REVIEW, W. Foreman Collins, A. H. England, Charles K. Harding, R. M. Johnson, W. J. Cooke, D. F. Morris. A pleasant surprise in the way of refreshments was arranged by Messrs. Monroe and Cavell, of the *Street Railway Gazette*. This made the trip a very delightful one, which was enjoyed by all.

Ernest L. Clark, of the Illinois Electric Material Company, of Chicago, Illinois, was present, and displayed some novelties in overhead switches.

The Electric Merchandise Company was ably represented by A. H. England.

The banquet, which was given in the rooms of the Columbus Club, was enjoyed by all.

# CORRESPONDENCE.

## OUR BOSTON LETTER.

**The Edison Illuminating Company,** of this city, has just finished laying the three cables of 350,000 circular mills under the Congress street draw bridge. The main will be connected directly to a 20 horse-power motor in one of the stores on Congress street extension. The company has just added five 125 horse-power engines to its station equipment in the first district on Head Place and four engines of 125 horse-power each in the second district station.

**Mr. Geo. W. Davenport,** the efficient manager of the Boston department of the Thomson-Houston International Electric Company, will probably represent his company in Europe after January 1.

**Mr. James L. Kimball,** of the Thomson-Houston Electric Company, and one of the inventors of the popular "K. W." rosette, has returned to his home in this city after an absence of several months.

**The American Bell Telephone Company** denies the report that it is about to sell telephones for private use.

**Mr. Warren S. Hill** has been unusually busy during the past fortnight getting his new company's affairs into working order, and it is gratifying to note that Mr. Hill's new enterprise is in excellent shape for business and starts off with a long list of orders and brightest of prospects.

**The Eddy Electric Manufacturing Company** has just finished the installation of an electrotyping plant at the foundry of Mr. Geo. W. Scott, Estes Press Building, this city. The machine was placed in position under the supervision of Mr. Arthur H. Eddy. It is a No. 3 machine and has a carrying capacity of 1,600 square feet.

**Captain Brown S. Flanders** has been appointed inspector of wires for the city of Boston by Mayor Hart, and his term of office will not expire until April 30, 1891. Capt. Flanders has been the efficient head of the fire alarm department of this city since 1873. His reputation as a reliable officer and expert electrician, together with a widespread popularity, proves that this wise and excellent appointment by Mayor Hart was made for the benefit and protection of the people of Boston and not as a political move.

**Ladies' Electric Club.**—A number of the most wealthy and intelligent ladies of Augusta, Maine, organized a Ladies' Electric Club recently for the purpose of securing funds to light the streets of that city by electricity. Last week the club held a Fair, which lasted two days and terminated with a grand concert and ball. The proceeds from the entertainments realized to the club a much larger amount than had been anticipated, which ensures the success of the object the members had in view. W. I. B.

Boston, Mass., Nov. 22.

## OUR CHICAGO LETTER.

**The Trouble** between the telegraph operators and companies throughout the West, which has been brewing for some time past, according to the last reports, has been settled. Reports have recently come in of small strikes at St. Louis and Kansas City, but the leaders of the Brotherhood claim at present they are not strong enough to fight the companies.

**The Residents** of Hyde Park are much elated over the fact that the plant of the Hyde Park Thomson-Houston Light Company has been started; this being the first plant in Chicago especially designed for lighting residences. The new plant is situated at Fifty-third street and Illinois Central Railroad tracks.

**The First Trip** of the Accumulator Company's storage battery car in Chicago was made to-day, on the lines of the North Chicago Street Railway Company. Through the kind invitation of William Hood, a number of gentlemen were present, including your representative. The car left the power house of the railroad company at 3.10 P.M., and made the run to Laurence avenue, 3¼ miles, in 17 minutes, returning over the same ground in 13 minutes. At one time during the trip a speed of 20 miles per hour was attained. Satisfaction was expressed on every side and the trip enjoyed by all. D. B. D.

Chicago, Nov. 22.

## PERSONAL.

Mr. Wm. H. McKinlock, president of the Central Electric Company, Chicago, was a New York visitor last week, and made his headquarters at the Electric Club.

Mr. Cyrus O. Baker, Jr., of Newark, N. J., accompanied by his wife, returned from a six weeks' European trip, Wednesday of last week, having greatly enjoyed his brief sojourn in other lands. In London and Paris, Mr. Baker met Lieut. Toppan, U. S. N., a well-known member of the Electric Club, who, with his wife, is enjoying a lengthy visit abroad.

## Telephonic News

*** A private telephone line is to be laid from Ticonderoga to Orwell, Vt., including a cable link of 500 feet across Lake Champlain.

*** Manager Springer, of the Muncie, Ind., telephone exchange, has just finished putting telephones in all the school buildings in the city.

*** The St. Paul, Minn., Telephone Company began the work, last week, of chopping down its poles throughout the city that have been rendered useless by reason of the wires going underground.

*** At the meeting of the Bell Telephone directors, held in Boston, on November 13th, nothing but routine business was transacted. The subject of a new stock issue received no discussion whatever, we are informed.

*** The Swedish telephone management has devoted 1,600 kronen towards the expenses of sending an expert to visit Holland, England and America, with the view of ascertaining the latest improvements made in telephony.

*** R. B. Rood, recently manager of the Savannah, Ga., telephone exchange, has gone to Richmond, Va., to assume charge of the exchange there. R. H. Polk, the manager of the Savannah Exchange, was formerly stationed at Montgomery, Ala.

*** If there is one thing Pierre lacks as a city it is a telephone system. Pierre is peculiarly situated for the success of an undertaking of this kind, the principal points of business being unusually scattered. Give us a telephone.—*Pierre, S. Dak., Capital.*

*** A system of "telephoned messages" has been organized in Paris. For a fee of 50 cents a message may be telephoned to any one of eight central offices in various quarters of the city, after which it will be delivered to its address by special messenger. The message is not to exceed 100 words.

*** The New England Telephone Company have served a notice on their subscribers in Danvers, Mass., that 30 days from date telephone service in that town will be discontinued. They have also notified the town to remove all electric light wires from their poles. It is understood that this action is taken because the town will not grant rights for poles as now set, the law now requiring written permission.

*** Seven directors of the Erie Telephone Company, residing in Lowell, Mass., were taxed in 1889 on $160,000 of stock of the Erie, Northwestern, Southwestern and Cleveland Companies, the stock of the three latter companies being owned by the Erie, the directors holding the stock of the three companies as trustees. The Lowell assessors taxed each Erie director living in Lowell, on $25,076. A hearing was begun before the assessors last week, to have the taxes removed, the claim being made that the three minor companies pay taxes in the West, and that it is hardship to make them pay also in Lowell.

*** A suit against the Philadelphia Bell Telephone Company was entered on November 12th. Charles Gilbert, who seeks to recover damages from the company for personal injuries which he claims to have received through their negligence in not keeping their telephone wires in order. In his statement of claim Gilbert says that on the evening of August 24th last he was riding on top of a train of cars as brakeman. In crossing Germantown avenue at Canal street he was suddenly caught by a telephone wire, which had become loosened from its fastenings, and brushed off the top of the car and thrown violently upon the pavement. He claims that in his fall he was seriously hurt in his back and side, besides sustaining internal injuries. The suit for damages is brought against the company upon the ground that the accident was caused through their carelessness.

## THE ELECTRIC CLUB.

A THOUGHTFUL AND INTERESTING ADDRESS DELIVERED BY PROF. E. L. NICHOLS, THURSDAY EVENING, NOVEMBER 20.—THE DISCUSSION.

The large front parlor of the Electric Club was crowded with members and their friends, Thursday evening, November 20, brought together by the announcement that Prof. E. L. Nichols, the able young professor of physics at Cornell University, was to deliver an address on "The Artificial Light of the Future."

Before the address was delivered, 50 odd members of the Club gathered together in the dining-room and in the downstairs café, and enjoyed the excellent *table d'hote* dinner. Among the gentlemen present during the evening were: Eugene Frayer, Lieut. Smith, U. S. N., A. Theo. E. Wangemann, P. H. Alexander, T. Mosher, J. M. Orford, John C. English, E. B. Baker, New Haven; R. M. Bailey, Williamsport; W. T. Beidler, Baltimore; E. E. Bartlett, F. G. Burton, G. B. Coggeshall, Jarvis B. Edson, W. H. Fleming, F. Gottschalk, W. J. Hammer, G. T. Manson, Dr. O. A. Moses, F. Z. Maguire, Geo. M. Phelps, Lieut. F. Jarvis Patten, H. A. Reed, John A. Seeley, W. D. Sargent, A. L. Salt, J. H. Seymour, C. E. Stump, T. C. Martin, Jesse M. Smith, Detroit; Dr. Leonard Waldo, P. B. Shaw, Williamsport; Nikola Tesla, Joseph Wetzler, W. J. Johnston, C. D. Shain, C. A. Lieb, S. L. Coles, Geo. Prescott, Jr., Robert H. Read, U. N. Bethel, J. H. McGraw, J. D. Bishop, B. G. Loomis, Emil Kipper, Zylonite, Mass.; Emil Mannesman, of Renscheid, Germany, member of the Verein Deutscher Ingenieure.

President Madden, of the Club, was unable to be present on account of a severe cold, and vice-president W. D. Sargent presided.

Before introducing the lecturer, an amendment to the constitution and by-laws was presented, which suggested that the dues of the non-resident members be reduced from $30 to $20 per year, and that a new classification of membership be made to include associate members, who were to pay the nominal sum of $12 a year, and receive all the benefits of the Club except that of holding office and voting. Under the by-laws, this proposed amendment went over until the next regular meeting in December.

Chairman Sargent then introduced Prof. Nichols, who spoke as follows, illustrating his lecture with lantern slides:

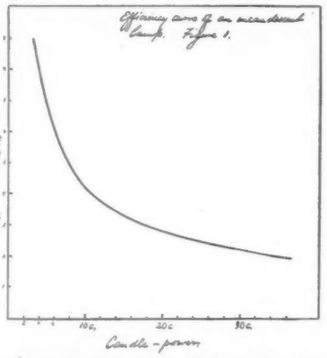
### "THE ARTIFICIAL LIGHT OF THE FUTURE."

The growth of electric lighting forms one of the most brilliant chapters in the history of invention. The record is one of which the electrician has reason to be proud. It is a record of advance following advance in our means of generating current and of transmitting it. It is the record of the evolution of the arc lamp from the first crude forms to the perfectly regulated lamp of to-day. It is the record of the development of the incandescent lamp. Throughout it all we note with wonder that the perfecting of 10,000 details of construction has gone hand in hand with ever diminishing cost of production.

As we review the history of the electric light, however, we find that in two respects there is less cause for congratulation. When we come to consider the quality of the light produced and the efficiency of the apparatus as a light-making machine, we find that the incandescent lamp of to-day produces the same quality of light which the earliest examples of its type were capable of giving. We find, however, that its light differs but little from that obtained by burning oil and gas, which, in turn, in spite of all the improvements which have marked the growth of artificial illumination, is almost the same in quality as that which the Eskimo obtains from the crude blubber of the whale, or which the dweller in the log cabin on the frontier may get from his home-made tallow dip.

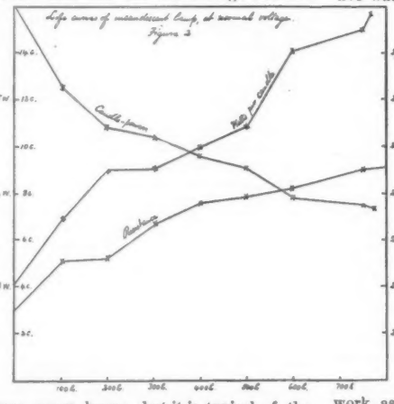
It is true that the efficiency of the incandescent lamp has gradually risen from five to three watts per candle, but those who have had occasion to trace the discouraging life curves of such lamps, may know how little real progress the change implies. We may start a well manufactured lamp at any temperature we please, provided that we do not pass a certain limit, beyond which the life of the lamp would be too seriously curtailed. The initial efficiency may be made as large as we please, within that limit; but it is only a question of a few days or hours when the lamp will have dropped to the dead level of mediocrity, the five watt level which seems to mark the confines of permanency in the case of incandescent carbon.

When we take a lamp and raise its electromotive force step by step, measuring the current, voltage and candle-power at each stage of the experiment, and plot the curve which expresses the relation between the energy required and the light produced, we are gratified at the marked rise in efficiency which follows each slight increase in the temperature of the filament. (Fig. 1.) That rise of temperature, however, means shortening of the life of the carbon, is well known. Mr. John W. Howell, in a valuable paper read before the American Institute of Electrical Engineers,* has given us abundant data upon that point. Unfortunately, rise of temperature means much more than that. I will venture to show you a few life curves recently obtained in the laboratory of Cornell University. These curves enable us to see at a glance what happens during the curtailed existence of a lamp which is forced to undue brilliancy. I introduce them because they indicate very definitely the nature of the difficulties which confront us when we




endeavor to increase the efficiency of an incandescent lamp by raising its temperature.

In the first instance, a lamp was started at the candle-power indicated by the maker, and was held at constant voltage by means of the current from a storage battery. The initial candle-power was 16, which was obtained at the expenditure of 3.015 watts per candle. Measurements of electromotive force and current were made at intervals of about 10 hours, during the 800 hours that the lamp lasted. The candle-power was redetermined at intervals of about 100 hours. The voltage never rose more than 0.65 volts above its initial value, and then only for a short time. The average electromotive force of the entire run was 0.40 volts below the initial value. The record of this lamp is contained in Fig. 2. It represents an individual case and not the average obtained




from many lamps, but it is typical of the results which have been obtained with many. The characteristic features are rapid, followed by slower falling off in candle-power, the decrement amounting finally to more than 50 per cent., and rapid, followed by slower falling of efficiency, to a final value of 5.75 watts per candle. These changes were accompanied by continuous and marked increase in the resistance of the filament.

If it be asked whether this individual case represents a state of affairs common to all incandescent lamps, I can only say that in my experience, which is certainly much less extensive than that of some others, I have known of no class of lamps, the performance of which did not agree approximately with that indicated by these curves. Mr. W. H. Pierce,† who described extended tests of the initial and average efficiency of incandescent lamps in a paper read before the Institute of Electrical Engineers some time ago, recorded no exceptions to this rule of decreasing candle-power and efficiency with time.

This falling off in candle-power exhibited by lamps maintained at constant voltage can be met by a procedure not easily applicable perhaps in commercial work, but readily carried out where the object in view is simply to study the behavior of the lamp under unusual conditions. The method consists in raising the electromotive force at short intervals of time by amounts sufficient to restore the candle-power to its normal value.

The results of such an experiment performed upon a lamp precisely similar to that from which the curves in Fig. 2 had been obtained, are depicted graphically in Fig. 3. Under this treatment the life of the lamp in question was not quite 100 hours. The total rise in electromotive force during the test amounted to about nine volts; the efficiency decreased from 3.118 watts per candle to 3.468 watts per candle. The resistance of the filament rose from 221.6 to 234.8 ohms. During the first 50 hours the changes were slight, then occurred a sudden increase of resistance, accompanied by marked rise in electromotive force and in amount of energy consumed.

The life history of the incandescent lamp at still higher temperatures does not differ essentially from that which we have just been considering, but the changes in question go on much more rapidly.

In Figs. 4 and 5 are recorded the performances of two lamps which were similar to those from which the curves in Figs. 2 and 3 had been obtained. The first of these (see Fig. 4) was started at 57 candles. It was maintained at constant voltage for 11 hours and 30 minutes, when it went out. During its brief life the candle-power fell to 24.6c. and the watts per candle increased from 1.58 to 3.09. The loss of candle-power during the experiment was 55 per cent., an amount which corresponds very closely with the loss suffered by the first lamp tested during the 800 hours that it lasted. In the case of the other lamp (see Fig. 5), the initial candle-power (64 candles) was maintained throughout. Its life under these circumstances was 140 minutes, during which short period it had been found necessary to raise the electromotive force from 114.08 volts to 129.53 volts. The efficiency of the lamp fell, meantime, from an initial value of 1.33 watts to 1.677 watts at the end of the first hour; then more and more rapidly to 1.945 watts at the end of the test.

The conclusion to be reached from these data, and from the great mass of experimental results which has accumulated since the incandescent lamp has become an object of investigation, is only too evident. The efficiency of an illuminant in which carbon is the glowing material, is a function of the temperature. It appears that the incandescent lamp is fairly stable only at temperatures for which its efficiency does not exceed about five watts per candle. We have just seen what occurs when one attempts to maintain lamps at degrees of incandescence corresponding to a much higher temperature. It is, perhaps, not possible to point out with perfect definiteness all the causes that are at work to reduce the candle-power. The black coating which gradually forms on the interior of the lamp bulb intercepts more and more of the light from the filament as the age of the lamp increases. The growth of this film and its power of absorbing light have recently been carefully studied by two of my advanced students, Messrs. B. E. Moore and C. J. Ling.

The life curves which I have just shown you were made by them as a necessary part of their investigation of the loss of light due to the opaque film, and I will venture to take from their work, as yet unpublished, the results which they have obtained in the case of the lamp to which the curves in Fig. 2 refer. These results are given graphically in Fig 6. They show the amount of light of each wave length of the visible spectrum which the coating on the interior of the bulb absorbed. The measurements were made after the lamp had been in operation 100 hours, 200 hours, 400 hours and 800 hours. In the diagram, abscissæ are wave lengths and ordinates show the amount of light transmitted by the lamp bulb at the above mentioned times, in terms of the amount which the bulb allowed to pass before the coating began to form. You will see by a glance at these curves that the absorbing power of the film was very nearly uniform throughout the spectrum, so that the blackening of the lamp had no appreciable effect upon the light which it emitted; also that the absorption at the end of 200 hours was considerably more than half as great as that at the end of 800 hours, and that the total loss of candle-power due to blackening was about 22 per cent.

These measurements enable us to account

* John W. Howell: Transactions of the Am. Institute of E. E., vol. v, p. 237.

† W. H. Pierce, Transactions of the American Institute of Electrical Engineers, vol. vi, p. 226.

for rather more than one-third of the loss of candle-power suffered by the lamp. We are not with our present knowledge in position to speak so definitely concerning the other two-thirds, but the increase in the resistance in the carbon indicates another source of diminution. That gradual failure of the vacuum which the use of the spark-coil would unquestionably have enabled the observers to detect, may well be answerable for the rest. Now, the temperature of an incandescent lamp filament at five watts per candle is very nearly the same as that of the carbon in the light-giving flames produced by the combustion of oils and gas, and it appears that the attempt to pass this temperature introduces difficulties of such a nature as to lead to the serious question whether we have not reached a definite limit, beyond which incandescent carbon ceases to be permanent.

At that limit the efficiency of the lamp is very small indeed, 95 per cent. or more of the radiant energy emitted being of wave lengths too long to afford light.

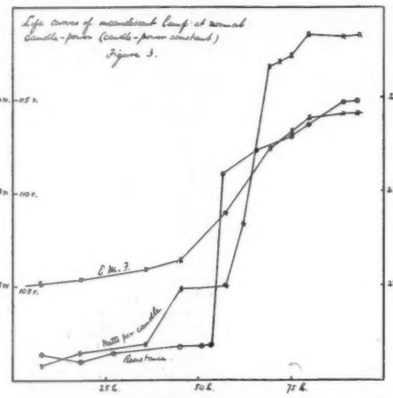
As to the arc light, no more encouraging report can be made. On the contrary, it is perfectly well established that the quality of the light, instead of increasing, has fallen off, in the course of the development of the lamp from the clock-work regulators of Duboscq and Foucault, with their slender carbons, to the commercial lamps of to-day.

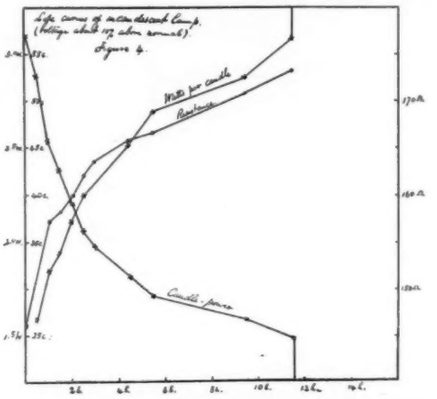
The researches of Nakano,* Marks† and others, show that the efficiency of the arc is a definite function of the current density at the terminals of the carbons, increasing nearly in inverse ratio to the cross section of the pencil. When the maximum current capacity of the latter has been reached, the efficiency is in the neighborhood of 10 per cent., a value which is not likely to be greatly exceeded by any of the methods in vogue at the present day.

As Mr. Edward Weston‡ says, in his discussion of Nakano's paper on the efficiency of the arc lamp: "The small amount of luminous energy, compared to the total energy employed, is a sad thing always."

In the vast accumulation of experience which the past years have witnessed, nothing has come to general knowledge which looks to the raising of the barrier which blocks our progress. It seems only too probable that the limiting temperature at which carbon can be used for the production of light has been reached, and with it the maximum efficiency of artificial illumination.

The phenomena observed whenever we attempt to raise carbon above what may be termed its normal temperature of incandescence are significant, and they all point in one direction. We have just seen that when we raise the voltage of an incandescent lamp, we gain splendor of performance at the cost of permanence and stability. I might remind you, in this connection, that when the heat of gas flames is increased by forced draft, they become non-luminous; that the magnificent illuminating power of the arc lamp is not due to the intensely hot electric arc itself, filled, though it be, with carbon in process of transfer from the positive to the negative pencil, but to the cooler carbon terminals. Such are the facts with which we have to deal when we consider the problem of increasing the efficiency of illumination by carbon; whether by direct combustion, by incandescence in vacuo or by the use of the electric arc. In the face of the many unexpected things that have been accomplished through the agency of electricity, he would be rash who asserted that the possibilities of carbon had been exhausted. In view of the achievements of the time one is not permitted to declare the case hopeless; nevertheless, the outlook is not an encouraging one.



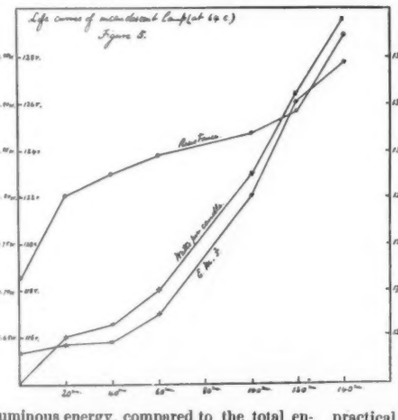



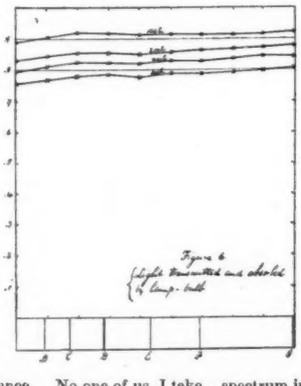

If, in what I have said thus far, I have drawn what seems to be a gloomy picture, it is not because I fail to recognize the importance of the electric light of to-day as a factor in our civilization. Its superiority over other methods of artificial illumination is so well understood that it need not be enlarged upon here. Of its advantages we hear on every hand; of its limitations we hear less; and yet a knowledge of the latter is quite as important to those who are interested in its further development. The waste of 90 or 95 per cent. of non-luminous energy in the production of light is a matter to which we are apt to give little thought, and when the economic importance of the fact has been forced upon us by the study of the recent investigations which have been made to establish it, we find consolation in the thought that, after all, those percentages are somewhat larger than the corresponding values for candles, oil and gas.

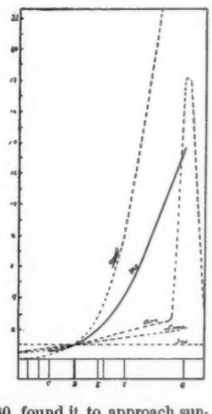
As time goes on, however, the question of the efficiency of illuminants will increase in practical importance. No one of us, I take it, is of the opinion that the world will always be content with the present extravagant methods of obtaining light. Progress in these matters is chiefly a question of the careful and exhaustive study of the properties of the substances with which the inventor and engineer have to deal. As in the past, so to-day and in the future, researches in the laboratory must prepare the way for operations in the workshop and manufactory. I have thought it not without interest, therefore, to discuss the behavior of incandescent carbon under conditions, some of which are not "commercial," and to attempt to point out the significance of that behavior. Now, if you will permit me, I will turn toward the future and consider the properties of some other sources of light, with the view of inquiring whether they may not have a part to play in the artificial lighting of days to come.

What is to be the light of the future? From the standpoint of the engineer, I will frankly say that I cannot answer that question, but abandoning the directly practical point of view, there is something to be said. I need offer no apology here for presenting facts, the application of which is at best remote, and the present importance of which is, therefore, rather scientific than utilitarian; nor need I remind you that all the so-called "forces of nature" which have been yoked and impressed into the service of man were the object of scientific curiosity and the subject of scientific investigation long before the idea of a practical application was entertained.

The number of elements and of compounds capable of sustaining a high temperature without dissociation or change of state is very large. Carbon is the only one of these, the capabilities of which as a source of light, can be said to have been fully tested; and yet all the others, when heated to a proper point, emit light-giving radiation. Take for example the metallic oxides. We heat the oxide of calcium in our magic lanterns and it gives us a light of great intensity and but little inferior to the arc light in whiteness. The exceeding clumsiness of our method of rendering it incandescent, however, has prevented its adoption excepting for certain special purposes. We burn magnesium in fire-works and for photographic flash lights, and occasionally we indulge in the luxury of igniting a bit of the ribbon and admiring, for an instant, the intense brilliancy of its flame. Now, magnesium is one of the most abundant elements on the face of our planet. It is a rather costly metal at present, being quoted at 50 cents an ounce in this country and at about half that price on the continent of Europe. Even under the limited demand for it which exists at present, it has fallen to about one-tenth of its price of a few years ago, and I feel sure that it lies within the power of the electrician to greatly further reduce the cost of production. Among artificial illuminants, magnesium has in one respect no equal. W. H. Pickering, who studied its spectrum in 1880, found it to approach sunlight in quality even more closely than the electric arc light does.*



The precise character of the magnesium light is shown in Fig. 7. The abscissæ of the curves are wave lengths, and ordinates indicate the brightness of each portion of the spectrum of the magnesium flame in terms of that of the corresponding regions in the spectrum of gas light. The accompanying curves for the arc light and the lime light, introduced for convenience of comparison, are from measurements by Mr. W. S. Franklin and myself. These curves all refer to lights of the same candle-power. It will be seen that the magnesium flame is about 10 times brighter in the violet than a gas flame of the same power, and but little more than half as strong in the red. It will be seen, also, that it surpasses the electric arc everywhere beyond the yellow, save in a

* Hatsune Nakano: Am. Institute of E. Engineers, vol. vi, p. 308.
† Louis B. Marks: Am. Institute of E. Engineers, vol. vii, p. 175.
‡ Edward Weston: Am. Institute of E. Engineers, vol. vi, p. 20.

* W. H. Pickering: Proceedings of the American Academy of Arts and Sciences, vol. xv, p. 240.

(*Continued on page 170.*)

## TELEGRAPHIC

.... The Western Union is making strenuous efforts to avoid putting its wires underground in Minneapolis, Minn.

.... A fire in the Western Union telegraph office, at 66 Gold street, New York city, on November 19, caused $100 damage.

.... The Gold and Stock Telegraph Company, of California, has sued Andrew White, of Oakland, Cal., to recover $11,549.34, which he collected in December, 1889, and January, 1890.

.... A sheriff in Winslow, Me., arrested a prisoner for drunkenness, and instead of jailing him, placed the man's arms about a telegraph pole and fastened them there with handcuffs. The prisoner was exposed to the cold for several hours. The sheriff may get into trouble.

.... The new line of the New Jersey Postal Telegraph Company will be completed to New Brunswick in about four weeks. The local wire will extend from Newark by way of Plainfield. Another line will run from Newark by way of Elizabeth and Rahway to New Brunswick.

.... The Commercial Cable Company has opened an office at 4 Charing Cross, opposite the Grand Hotel, London. This was made necessary by the demand for direct communication between the West end of London and the United States and Canada. This company's connection with the Postal Telegraph Company of the United States and the Canadian Pacific Telegraphs of Canada, gives its patrons very rapid and reliable service between the two countries. The new office will be kept open from 7 A. M. till midnight.

.... The Mutual District Messenger Company was incorporated at Springfield, Ill., last week, to do business at Chicago, with a capital of $50,000. Harold A. Douglas, formerly assistant superintendent of the telephone company, who had charge of the messenger service; George W. Conover and William Taylor, both connected with the electrical supply business, are the incorporators. The company will be in opposition to the American District Telegraph Company, and Mr. Douglas, who has had considerable experience, will probably be manager. A large amount of the stock has already been subscribed, and there is said to be good financial backing behind the company.

.... Jabez Fearey, the manager of the Postal Telegraph Company, at Newark, N.J., died early in the morning of November 16, at Farry's Hotel, Matawan. He was 52 years old and was born in England, coming to this country when about five years old. He was a soldier in Company K, Second New Jersey Volunteers, and he lost an arm at the battle of South Mountain on Sept. 14, 1862. Early in 1863 he entered the service of the Western Union Telegraph Company in Newark, and afterward operated the Newark offices of the Pacific and Atlantic and the Atlantic and Pacific until they were absorbed by the Western Union. After that he was the manager of the Western Union offices in Newark up to September 1 of this year, when his contract expired, and he would not renew it because of a disagreement about percentages. He ran the only contract office the company had in this country, and in addition kept an office which was unique, inasmuch as it was a general information bureau, ticket office, sub-post office, municipal messenger office, burglar alarm office, steamship, foreign draft, insurance and advertising office and cigar store. It was the center of news in Newark, and the place where the most prominent men in Newark met by appointment. Mr. Fearey was extremely popular, but never held any political office except that of school commissioner. He leaves a wife and three children.

* * The Calumet Electric Street Railway Company, of Chicago, filed a certificate of increase of capital stock to $500,000.

* * The electric street railway from Albuquerque, N. M., to the Mesa, east of the city, is now said to be a sure thing.

* * Kankakee, Ill., is after an electric railway. A company has made a proposition to the council to put in a plant worth $100,000 if granted the franchise.

* * The city council of Beaumont, Texas, has granted a franchise to the Beaumont City Street Railway Company to put in an electric belt line. Construction will begin at once.

* * The Binghamton, N. Y., Street Railway Company has made application to the State authorities to change the motive power on the Clinton street railway from horse to electricity.

* * The track of the steam division on the St. Louis and Suburban Railway will be widened at an early date, and the motive power from the passenger depot on Vandeventer avenue to Florissant, the present terminus of the road, changed to electricity. The company will probably put on hourly trains, which will materially improve the traffic and aid in developing that portion of the country.

* * The Haverford, Pa., Electric Light Company has doubtless assisted in Ardmore's boom. The company's wires stretch about four miles in one direction and nearly five miles in another. They supply electricity for 1,500 lights and a number of motors at private residences for operating the small pumps by which water is forced from wells to reservoirs in the top stories of the dwellings. The company uses a storage battery, and all the electricity sold is measured by meters. Jacob L. Stadleman employs one of the company's motors for operating his saw and planing mill.

* * Advices from New Bedford, Mass., under date of November 10, state as follows: Negotiations are pending for the purchase of the entire plant of the Union Street Railway Company, of this city. The Standard Oil Company is supposed to be conducting the negotiations through representatives who have recently been here and have held a conference with officials of the company. The contemplated change meets the approval of the public in general. It is stated that the change of management will wholly do away with the objectionable three cent transfer recently imposed, and that the electric system will be generally adopted. Crosstown lines will be built, and some of the remote sections of the city will be connected by electricity with the city proper.

* * The Brooklyn Club has changed presidents, it is said, because the incandescent light was adopted. The former president, Mr. David M. Stone, said: "What! have that highly dangerous and perniciously unhealthy electric glare in the club house? Never! I protest." President Stone's voice was the only one, however, that was raised against the innovation, and it was voted that the lights should be put in. Each morning on his way to his office, it is said, Mr. Stone stopped and inquired if operations had been begun, and each morning the answer was "no"—until one morning it was changed to "yes." Whereupon Mr. Stone, as soon as he reached his office, sat down and wrote his resignation as president and director of the Brooklyn Club. This was promptly accepted, and at a subsequent meeting of the board of directors, General H. W. Slocum was elected in his stead. This is a clear case of progress—a triumph of modern ideas—and soon, we predict, Mr. Stone will admit that he made a mistake in opposing the improvement.

## OUR MINNEAPOLIS LETTER.

**The Minneapolis Telephone Company** is the victim of a peculiar accident by which it incurred losses aggregating $5,000. By some means the guy wire, which sustained a pole bearing a heavy network of wires, was severed and the pole, which was an exceptionally large one, fell across the street, striking and injuring a teamster, crashing through a store front and doing other damage. The aggregate damage was not less than $5,000. It is supposed to have been the work of a telephone subscriber with whom the company has had trouble.

**The Minneapolis Edison Light and Power Company** is preparing for the occupancy of its elegant new office quarters on the ground floor of the Lumber Exchange. These quarters open from the entrance on Hennepin avenue, used for their power building, and could scarcely be improved upon in the matter of convenience. The Edison Light and Power Building, which is a part of the Lumber Exchange, is rapidly filling with tenants and the company believes its entire 12 floors will be fully occupied within a year after its completion.

**A Vigorous Complaint,** accompanied by some curious charges, was lodged with the city council at its last meeting against the Minneapolis Street Railway Company. It came from Southeast Minneapolis citizens living along the new inter-urban electric line, who charge that President Lowry has been paid by the short line railway companies to abandon his franchise for the operation of that line between Minneapolis and St. Paul. Mr. Lowry's contract with the cities provided for the completion of this line before November 1, 1890. The road is now completed and Mr. Lowry has promised to get it in operation by the 15th of December, 1890. Though these charges are seriously and vigorously made, it is not generally believed that there is anything in them, and the council will not at present take cognizance of the matter.

**The St. Paul Telephone Company** has asked and secured an extension of time for the laying of its underground conduits in that city. The work should have been completed November 1st, but delay in securing material prevented. The Minneapolis company has its work in this direction completed for the year, and occupies a new and convenient central office.

**The Robinsdale Electric Railway Company** has commenced and is rapidly pushing work on its line from the city limits on Thirty-second avenue to the suburb of Robinsdale. Stockholders of the Northern Car Company, at Robinsdale, are largely interested in this line and will furnish its equipment.

**An Important Suburban Line** of electrical railway is projected by C. C. Dunn, Jacob Borge and W. A. Barnes, of this city, working in harmony with the Minneapolis Street Railway Company. It is to run on Sixth avenue from Penn avenue to Medicine Lake, Golden Valley and Plymouth. Articles of incorporation will be filed this week and the work of construction will be finished by June 1, 1891.

**The St. Paul City Council** has given the street railway company of that city an extension of time until March 1, 1891, to complete the electric system now in process of construction. The company will be compelled to ask a similar extension of time in Minneapolis, and there is little doubt that it will be accorded. The work has been phenomenally rapid in both cities, but unexpected delays in receiving machinery for the power houses have made it impossible to finish it as soon as the company expected to. The principal lines in each city, however, are now operated by electricity.

**A Writ of Injunction** has been granted by Judge Lochren to John G. Gluck, restraining the Minneapolis Street Railway Company from constructing an electric line on Hennepin Boulevard, one of the fashionable thoroughfares of the city. The trouble is an old one. Two months ago the council instructed the street railway company to construct this line, and the injunction is the result of an attempt to begin work.

**The Wisconsin Courts** have granted an injunction against the city of Stevens Point, restraining the council from issuing $10,000 bonds for the establishment of an electric lighting plant. J. C.

Minneapolis, November 19, 1890.

The Missouri Electric Light and Power Company, of St. Louis, will, between now and January 1st, make extensive improvements in their plant at Twentieth street and Lucas place. The company have just put in a new 6,000 light Westinghouse dynamo, but find they must enlarge their building in order to put in sufficient dynamo, engine and boiler capacity to meet the wants of their business, and will at once commence the enlargement by building a temporary building on the north side of the present one, and early in the Spring a permanent building will be erected, which will extend to the street line on Lucas place, thus making their entire plant cover the whole half block.

## On the Theory of Compound Winding for Constant Potential.

ABSTRACT OF A PAPER READ BEFORE THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, NOVEMBER 18, 1890, BY DR. LOUIS BELL.

I shall consider the subject synthetically rather than analytically, starting from the plain shunt winding and considering those terms which must be introduced to take account of the failure of shunt winding to give constant potential. I will introduce the following notation, which differs slightly from that most often employed:

Let $C_x$ represent the current on the line.
$C_s$, the current in the shunt coils.
$R$, the resistance of shunt coils.
$r$, the resistance of armature and series coils combined.

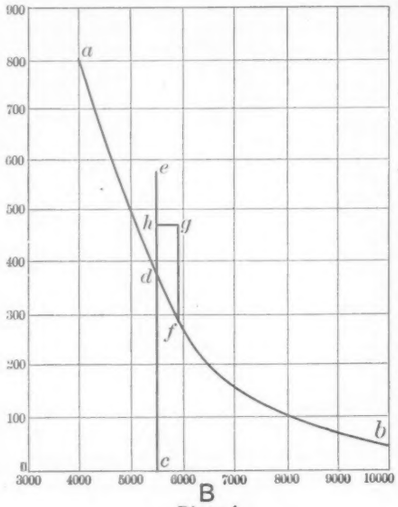



Plate 1.

$E$, the E. M. F. of the machine running light.
$e$, the fall of potential due to armature resistance.
$N$, the number of convolutions in shunt coils.
$n$, the number of convolutions in series coils.
$m$, the number of convolutions on armature.
$a$, $b$, $c$, the three terms of $n$.
$l$, the angle of lead.
$q$, the magnetic resistance of machine on open circuit.
$q_x$, the magnetic resistance of machine at full load.
$p$, the value of $q_x$ divided by $q$.

The first and obvious cause of fall of potential at the terminals of the machine is due to the fact that the armature has a resistance; as the current increases, a certain amount of potential is absorbed in the armature, and consequently, the available E.M.F. at the terminals falls. The amount of decrease is evidently proportional to the resistance in the armature and the current through it

$$e = r\,C_x$$

To compensate this loss we must furnish an increase of induction sufficient to produce $e$ additional E.M.F. If the field magnets and the armature core were quite unsaturated, we should simply increase the total ampere-turns to an amount sufficient to compensate the fall in potential. Let $a$ be the series turns capable of producing this at full load, neglecting change in permeability, then

$$a = \frac{Nr}{R}$$

But the permeability decreases as we put on this additional induction. The magnetic resistance $q$, at the start, will have increased to a certain other value $q_x$. We must, therefore, increase the number of series turns,

$$a = \frac{Nr}{R}\,p$$

This quantity does not have to be multiplied by the co-efficient of leakage because we have simply reduced the shunt turns to equivalent series turns, and consequently have already included it. This formula will be at once recognized as practically equivalent to that given by Thompson.

It will be noticed that both $a$ and $b$ include the quantity $p$, and here is met the principal difficulty in effecting the compounding. It is my purpose to show that this quantity $p$ can be obtained from known data with sufficient accuracy for the purpose in hand. This quantity will be little in excess of unity and in practical machines may range from 1.05 to 1.50. Thompson gives the case of a certain Siemens compound machine in which $p$ would be over three. I give herewith the data for the Manchester machine described by Dr. Hopkinson. I have simply taken the apparent permeability from his characteristic curve.

| When magnetizing force = 1,000, | induction / magnetizing force = 470 |
|---|---|
| " " 2,000 | " 465 |
| " " 3,000 | " 460 |
| " " 4,000 | " 460 |
| " " 5,000 | " 460 |
| " " 6,000 | " 451 |
| " " 7,000 | " 443 |
| " " 8,000 | " 425 |
| " " 9,000 | " 400 |
| " " 10,000 | " 377 |
| " " 11,000 | " 353 |
| " " 12,000 | " 333 |

If the permeability curve of the iron is known even approximately, we can obtain $p$. In Fig. 1, let $a$ $b$ be the permeability curve. The permeability at no load corresponds to the point $d$, that at full load to the point $f$. Lay off the ordinate $d$ $e$ so that the ratio between $d$ $e$ and $c$ $d$ equals the ratio between the iron resistance and the air resistance of the proposed machine, then lay off from the point $f$ the ordinate $f$ $g$ equal to $d$ $e$, and draw $g$ $h$. The ratio of the lengths $h$ $c$ and $e$ $c$ corresponds to the quantity $p$ required. Fig. 2, drawn from Hopkinson's figures, gives numerically the change in permeability for cast iron. The figures relating to the Manchester machine were for wrought iron cores and cast iron poles. It is evident that a close approximation to the value of $p$ can be made if we know anything about the iron that we are going to use. Now $a$ and $b$ are of about the same order of magnitude. I do not think that $b$ will ever be negligible in a practical machine unless $a$ is also negligible, and there is, therefore, little need for compounding. The approximate demagnetizing effect of the armature has been investigated by Hopkinson and is,

$$4\,\pi\,C\,\frac{m\,2l}{2\,\pi} = 4\,l\,m\,C.$$

In other words, it is due to the convolutions included in twice the angle of lead. For constant potential we must add then $c$ turns in series equal

$$v\,m\,\frac{l}{\pi}.$$

It is evident at once that a change in lead will effect the compounding; an increased load will cause the machine to under-compound, a decreased load to over-compound. As, however, the amount of distortion in the field depends largely on the shape of the extremities of the pole pieces, the above un-

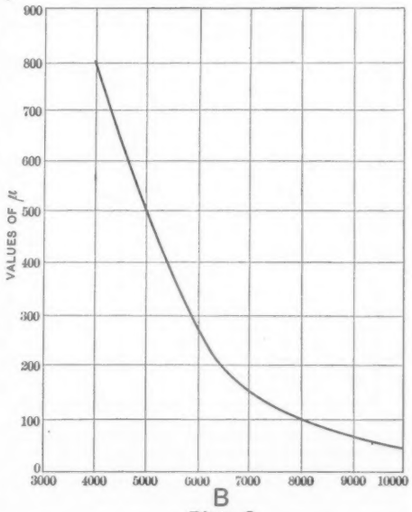



Plate 2.

certain factor in compounding can often be gotten rid of by a little care in designing the poles.

It is obvious that the term $c$ is to include the co-efficient of leakage. Uniting now, the three terms, $a$, $b$ and $c$, we have, finally, as the complete formula for compound winding, the following:

$$n = p\,\frac{Nr}{R} + \frac{\frac{NE}{R}\,(p-1)}{C_x} + v\,m\,\frac{l}{\pi}$$

It now may be interesting to see how well this formula applies to practical machines. Machine No. 1, 110 volts, 8 amperes, over-

compounded 2 volts. For this small machine take $p$ equal to 1.2. Applying the formula, $a$ equal 14, $b$ equals 44, $c$ equals 15; total series turns by formula, 73; actual number, 90.

Machine No. 5, 500 volts, 60 amperes. $p$ equals 1.05 over-compounded about 7 per cent. $a$ equals 3, $b$ equals 5, $c$ equals 4; total 12; actual number, 32.

Machine No. 8, 100 volts, 30 amperes. $p$ equals 1.1, $a$ equals 13, $b$ equals 46, $c$ equals 45; total, 84; actual turns, 56. Machine over-compounded about 2 volts, and the shunt winding did not bring the potential up to the 100 volts intended.

These are merely rough figures, obtained without the use of even the permeability curve of the iron—simply by estimation from permeability curves at hand.

An approximate idea of the amount of irregularity in potential may be gained from Fig. 1. Connect in this diagram $d$ and $f$ by a straight line. From its middle point drop an ordinate upon the axis. The length intercepted between the straight line and the permeability curve then gives the error in compounding, by comparison with the total change of magnetic resistance.

The formula I have given determines the compound winding for a given assumed potential produced by a shunt coil alone; therefore, if the machine is to be run at a slightly different speed from that at first intended to produce this given voltage, the compounding is still correct, for it pertains to the voltage rather than to the speed. If the speed of a correctly compounded machine be raised and the current in the shunt kept constant, it will tend to over-compound. If the current in the shunt is allowed to increase, the change in resistance will decrease the relative power of the series coils, and the machine will under-compound.

All these attempts at the proper theory of compounding depend on forming some sort of an estimate on the change in magnetic resistance of a dynamo, due to adding a certain amount of induction. Without some approximate method of finding this quantity, the problem is indeterminate, and the special thing which I have endeavored to show is that from the data already at hand about iron, we can form a sufficiently close estimate of the value of the coefficient $p$, without either knowing the characteristic of the machine or indulging in endless approximations.

### Electric Lighting in Boston.

On the petition of the New England Shoe & Leather Association, praying that the Edison Electric Illuminating Company, of Boston, may be directed and required to supply the petitioners with electricity, the Gas Commissioners have passed an order, after hearing the parties in interest, directing the Edison Company to supply the petitioners with electricity for the purpose of lighting the buildings 114 and 116 Bedford street, as soon as the petitioners shall have run third, or neutral, wires of sufficient size from the switchboard in the building to the point of distribution in each of its stores; the electricity so supplied to be measured by meter and the price thereof not to exceed the price charged by the company to a majority of its customers.

On the petition of D. L. Sheplie and George E. Henry, asking that the Edison Company may be required to supply them, a similar order has been passed without the condition in the case above noted with regard to neutral wires, it having already been wired on the three-wire system.

It was held on the part of the Edison Company that the petitioners were not using the Edison lamp, and that the Boston company had made a contract with the present Edison Company, agreeing not to use or supply current for any but Edison lamps, the contract having been made prior to the statute of 1887 giving the Gas Commissioners jurisdiction over electric light companies. The board, however, decide that under section 2, chapter 105, Public Statutes, all corporations organized under the general laws are subject to such laws as are afterward passed and applicable thereto.

### A Jersey Club Meeting.

The Nineteenth Century Club, an electrical organization of Passaic, N. J., entertained about 75 of their friends at the Passaic electric light station the evening of November 18. Special trains of electric cars conveyed the guests to the station. The electric plant was inspected, and then a meeting of the club was held. President Willard H. Fuller introduced Mr. Lemuel Wm. Serrell, general manager of the U. S Electric Railways Co., of 10 Wall street, New York, who, in a conversational tone, read an interesting paper explanatory of electrical force, and gave a brief outline of the multitudinous commercial uses of electricity, together with a forecast of its future prospects. He was followed by Mr. Harold Swan with a paper on "Electricity in Modern Warfare." Dr. De Baun read a paper on "Electric Therapeutics," in which he showed the great aid the medical profession obtains from the new force. A short talk by Mr. Taylor on his experience in a balloon ended the entertainment.

### Electricity on our Cruisers.

Commodore George Dewey, Chief of the Bureau of Equipment, in his annual report to the Secretary of the Navy, says:

"The lighting of ships of war by electricity, which was begun by this government, has now become so essential that no war-ship is considered complete which is not so lighted. During the year substantial progress has been made in the development and advancement of the system which is being employed in the new ships, and progress abroad has been critically noted. Electric lighting plants have been placed on board seven vessels, and the work of installation is actively progressing upon four others.

"Special attention has been given during the year to the subject of means of interior communication on ship-board, and a telephone system is soon to be added experimentally to other devices in use on board one of the new cruisers. Night signaling by electricity has also been and is still actively under consideration, and it is believed that a system will have been devised in the near future which will meet the increasing necessity of the service in this respect. The great importance of an adequate method of communication at night between ships of a squadron or fleet, makes necessary the utmost care in the consideration of the subject."

### The Small Boy's Picnic.

Mr. Emerson McMillan, president of the Laclede Gaslight Company, of St. Louis, wrote Mayor Noonan an interesting letter last week, in which he stated that during the past five months 1,358 incandescent lamps have been destroyed by evil disposed persons. The Laclede Company furnishes 763 incandescent electric lamps to the city, in the northern part of the city, and Mr. McMillan says that nearly enough lamps have been destroyed during the past eight months to average two to each point where the lamps are placed, without including lamps that were burned out. Mr. McMillan concluded by requesting Mayor Noonan to do something to protect the property of the company.

### The Connecticut Electric Light Association.

The annual meeting of the Connecticut Electric Light Association was held in New Haven, Conn., Thursday last. The following officers were elected for 1890 and 1891: President, James English, New Haven; first vice-president, J. A. Hadley, Meriden; second vice-president, James P. Stow, Middletown; treasurer, John C. English, Bridgeport; secretary, A. M. Young, Waterbury. Members of executive committee, F. F. Tuessenich, Torrington; L. C. Whitney, New Britain.

—— The electric light company of Reno, Nevada, has levied an assessment of 15 cents a share, which will be delinquent on and after December 10.

—— Electric lights have been placed throughout the Santa Fe shops at Topeka, Kan., and the old hand-torches which for years have been used for night work are laid aside. A double force of men is now employed in the machine shops and blacksmith shops.

—— The ordinances authorizing the Diamond Electric Company and the Manufacturers' Electric Company to lay underground conduits in Philadelphia, will be favorably reported upon by the City Council in accordance with the direction of the Electrical Committee.

—— For over two years the city of Cleveland, O., has not advertised for bids for lighting the city. About two years ago an attempt was made to advertise, but the city auditor reported that there would be no use, as the lighting levy only amounted to $140,000 and the bids invariably to $160,000. Therefore, he could not certify to a contract, as there would never be enough money in the treasury to permit him to do so. Since that time the old contract has been continued from month to month. Recently an attempt was made to advertise for bids again, but the same old objection was raised. The present city controller thinks, however, it might be well to advertise and see whether the contract price could be got within the levy.

### To Determine Melting Points.

A. C. Christomanos gives an elaborate description of a new apparatus of his in the *Berichte der Deutschen Chemischen Gesellschaft*. He claims that, by means of it, a more correct determination of the melting point of substances may be ensured. The essential features of this apparatus are as follows: The cylindrical vessel, A, which is 12 cm. in height and 6 cm. in diameter, is heated on a sand bath or in an air bath, and is provided with two apertures; a thermometer, C, and a

Apparatus for Determining Melting Points of Metals.

platinum wire, $f$, pass through a cork fitting into one of the apertures, whilst the other, $c$, is conical and fluted, and serves for the reception of a drawn out test tube, B. The vessel, A, is filled with pure mercury to such a depth that the end, $b$, of the test tube is about 2 cm. below the surface, $a$ $o$, of the metal.

The substance is introduced in a melted condition into the end, $b$, of the drawn out test tube, so that it forms a layer of from 0.5 to 1.5 cm. in length, and when it has completely solidified again the test tube is placed in position, and the space, $a$ $c$, immediately above the substance filled with mercury, into which dips the platinum wire, $d$.

On applying heat, the mercury in A is uniformly heated throughout its whole mass, so that the thermometer and the substance are always at the same temperature. The moment the substance melts the two mercury columns come in contact, the circuit is completed, the bell, D, rings, and the temperature is noted.

—— The annual meeting of stockholders of the Edison Electric Light and Power Company, of St. Paul, was held last week, when the following directors were elected: N. C. Thrall, C. B. Lamborn, G. H. Finn, J. A. Barker, O. C. Greene, A. Marcus and J. H. Herrick. The officers of the company were re-elected. N. C. Thrall, president; C. B. Lamborn, vice-president; G. H. Finn, secretary, treasurer and general manager.

—— In a paper on the excavation of the new Croton aqueduct, Mr. J. P. Carson, of this city, says: "For the first two years gasoline torches, miners' lamps, a few candles and electric lights, to some extent, were used. The two former predominated. The air finally became so foul that an order was issued forbidding the use of torches or lamps, and after a time the torches were abandoned. In the construction of the masonry only candles and the electric light were employed."

—— The month of December promises to bring such a great amount of new business to the Westinghouse Electric Company, that it will probably receive the credit of being the "Red Letter Month" of the year. A large number of the older alternating current central station plants have made contracts with the company for an increase in their capacities, and among the new plants is one to be established at Kirkville, Mo., and another at Taylor, Texas. Each of these plants will have a capacity of 750 A. C. 16 candle-power incandescent lamps to start with, but it is expected that this will have to be increased very shortly. Including these two new stations, the Westinghouse alternating current system is now operated in more than 350 central station plants. The total capacity of these stations aggregate 700,000 lamps.

## Electric Light News

—— One acre of land, one house and $1,000 have been secured toward establishing an electric light plant at Radford, Pa.

—— The Philadelphia Electric Light Companies, we are informed, show an earning capacity for the year of 39 per cent. on the cash paid in.

—— The incandescent lamp department of the Thomson-Houston Electric Company, at West Lynn, is now turning out 28,000 lamps weekly. Four years ago the weekly product was about 1,800.

—— The fourth annual ball of the Aid and Benefit Association of the Citizens' Electric Illuminating Company, of Brooklyn, will be given at Saengerbund Hall on the evening of December 5th.

—— The Ogden City, Utah, Electric Light Company have their new power house nearly completed. The cañon plant will be abandoned, and the prospects are that Ogden will have plenty of light in the future.

—— Commissioner of Public Works, Thomas F. Gilroy last week gave a contract to the Edison Company to light up the dome of the New York City Hall. The power will be supplied by a neighboring dynamo. Fifty 16 candle-power lamps will be used.

—— There have been great objections raised to the rates charged to the city of Fall River, Mass., for street electric lights. The committee on lights has had a conference with the electric company, and has secured a reduction from 50 cents a light per night to 47 cents.

—— Electric lights and electric power can be used for anything nowadays. The other night a man who is painting a new house in Bangor, was seen in the middle of the road painting a window sash by the light which hung over the street.—*Augusta, Me., Journal.*

—— The Utica Electric Light and Power Company is greatly annoyed by the breaking of lamp globes in the streets. Large numbers of them have been broken by boys throwing stones. The company will pay a liberal reward to any one furnishing information leading to the punishment of such offenders.

—— N. W. Ingram, president of the Argentine, Mo., Water Works and Electric Light Companies, proprietor of a boot and shoe store in Kansas City, Kan., and of a general store in South Kansas City, Kan., made a general assignment last week for the benefit of his creditors. His assets are about $75,000; liabilities, about $30,000.

—— New Albany, Ind., is said to have more factories and mills than any other city of its size in the State, and it is continually pushing out and enlarging its area and increasing its facilities. Now comes the electric lights and an electric railway, which will probably continue throughout the entire present lines. So much for one little city with only 22,000 inhabitants.

—— The electric light plant in the Vanderbilt building, New York, which was illustrated in a recent issue of the REVIEW, is a practical illustration of the working of the Evans friction system. The engine is 50 horse-power, made by the widely known Fitchburg, Mass., Steam Engine Company, and the dynamo of the Loomis system. The engineer is well pleased with the entire plant.

—— The Western Isolated Lighting Department of the Thomson-Houston Electric Company, Chicago, reports the following recent sales: Weisel & Vilter Manufacturing Company, machinists, Milwaukee, Wis., 200 incandescent lights; Balatka Brothers' residence, 220 Fremont street, Chicago, 20 incandescent light plant; Soldiers' and Sailors' Orphans' Home, Knightstown, Ind., 400 incandescent lights.

## THE ELECTRIC CLUB.

(*Continued from page 167.*)

very limited region of the extreme violet. In order to appreciate fully the significance of these curves, one must have had occasion to compare the various lights to which they refer, placing then side by side and noting the effects. You are all aware that the magnesium light is very white and very powerful, but unless you have happened to see it in direct competition with our ordinary illuminants, you will be but dimly conscious of the difference between them.

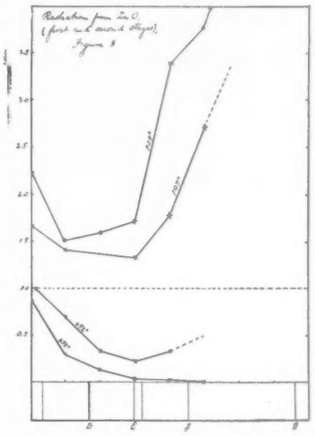
I have here a single magnesium lamp of European manufacture. By means of a simple arrangement of clock-work, it feeds a thin magnesium ribbon at a rate just sufficient to maintain a flame of between 40 and 50 candle-power. Turn your attention for a moment to the screen just behind us. It gives you the impression of a nearly uniform white surface, which is well lighted by the incandescent lamps with which this hall is so abundantly supplied. Its whiteness now, however, is a very different thing from that which it will take on under the rays of the magnesium light. I light the little clock-work lamp, placing it so that it illuminates a portion of the screen. That part which is shaded from the lamp is just as well lighted as it was before, and its tint is in no way changed; but no one would be likely to describe it as a white surface under the present circumstances. It has sunken by comparison into a rather weak chocolate brown. Let us turn the lamp so that you can see the burning magnesium, and place beside it, to emphasize the contrast, this lighted candle. How dull and sickly the candle flame appears, and yet, though old-fashioned and rather out of date among our modern glow lamps, the candle does not suffer greatly, so far as quality of light goes, by comparison with them.

I have been much interested in studying this source of light, and I will venture to give you some of the results which I have obtained. This lamp consumes 168 milligrammes of magnesium per minute. It is difficult to determine its candle-power by ordinary methods, because of the enormous difference between the color of its light and that of gas light. By means of measurements made with the horizontal slit photometer, an instrument the use of which entirely obviates this difficulty, I found the light to average slightly more than 40 candle-power. Assuming 40 candles to be the correct value, we have 4.2 milligrammes of magnesium consumed per minute per candle. Now to maintain one candle-power of gas light one minute with an average quality of illuminating gas, 137 milligrammes of gas must be consumed. With gas at $1.00 per 1000 cubic feet and magnesium at $10.00 per kilogramme, a price which is in excess of the present European rate, the magnesium light would cost, candle for candle, about 6.72 times as much as gas. With magnesium at $1.49 per kilogramme, or about 67 cents a pound, the cost of the two illuminants would be the same. Looking at the matter from a slightly different point of view, we may say, that since 4.2 milligrammes of magnesium will give as much light as 137 milligrammes of gas, their relative productiveness as illuminants is as 32.1 to 1. The true relation between their values is, however, expressed by a larger ratio than that since, candle-power for candle-power, the real worth of a source of light increases with its temperature. The total luminosity of the arc light, for instance, may be considered fully 25 per cent. greater than that of gas. Two candle-power of sunlight is the equivalent of three candles of gas light. The luminosity of the magnesium light lies between these two values.

The proper way to compare sources of illumination is to determine their net and gross efficiencies; by which I mean, respectively, the ratio of total radiation to light-giving radiation, and the ratio of the total amount of heat set free in the process of producing a candle-power of light, to the heat energy represented by the light itself. Now, the heat equivalent of a candle-power of gas or of the light of an incandescent lamp at five watts per candle, is about 3.6 gramme-calories per minute. The total heat of combustion set free in generating a candle-power of gas light has been variously estimated at amounts ranging from 971 gramme-calories per minute (Preece) to 4,100 gramme-calories (Thomsen). Calculations based upon the theoretical heats of combination of illuminating gases, give values nearer the latter than the former amount.

The amount of heat set free when a gramme of magnesium is converted into the oxide is very much less than that resulting from the combustion of a gramme of coal gas, and the light obtained is, as we have just seen, more than 32 times as great. The gross efficiency of the magnesium light must, therefore, be many times higher than that of gas light. To be exact, we find, if we adopt the value given by Thomsen* for the heat of combination of magnesium (6077.), that the magnesium flame of one candle-power should generate only 25.52 gramme-calories per minute. Taking the very low estimate of 1000. gramme-calories per minute for gas, *we find the gross efficiency of the magnesium flame to be about 40 times that of gas light.*

The simplest method of detetermining the net efficiency of a source of light is that recently applied by Mr. Merritt to the study of the incandescent lamp.* I have measured the efficiency of the magnesium flame by Merritt's method, which consists in receiving the radiation upon the face of a thermopile. A glass cell containing a solution of alum is placed between the flame and the pile. This cuts off almost all those rays which do not produce light and permits about 75 per cent. of the luminous waves to pass. After observing on a suitable galvanometer the deflection produced by the light giving radiation, the cell is removed and the deflection noted again. The ratio of these two readings, properly corrected, gives the net efficiency of the source of light. In the case of the magnesium flame, at least 15 per cent. of the total radiation was found to belong to the visible spectrum. Let us consider the matter from another point of view. When we disperse the rays from any source of light by passing them through a prism or reflecting them




from a diffraction grating, we find that we have to do with a great many rays which are of a wave length too great to affect the eye. These constitute what is called the heat spectrum, and they are accompanied by a few rays which are of the wave lengths capable of optical action. By means of the thermopile or the bolometer, it is possible to explore the whole spectrum, and to determine the intensity of the radiation of each wave length which the source emits. From these values the curve of distribution of heat in the spectrum may be plotted. The curve consists of two parts: That which gives the energy of the light-giving rays, and that which shows the amount of radiation outside of the visible spectrum. The ratio of the areas enclosed by these two portions of the curve is the net efficiency of the source of light. Such curves for the flames of candles, oil and gas show that less than two per cent. of the total radiation is luminous. In the case of the incandescent lamp the amount rarely exceeds five per cent. The arc lamp contains about ten per cent. of useful rays. The magnesium light, therefore, according to the data which I have just presented, possesses a much higher net efficiency than any of the other sources of artificial illumination. To what does it owe its superiority?

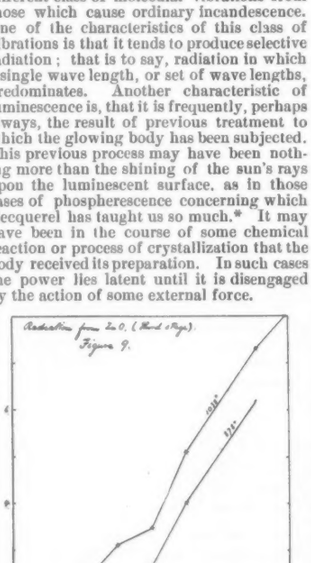
We have seen that, weight for weight, magnesium affords more than 30 times the light obtained from gas, with the development of much less heat. The quality of the light is such that merely from the standpoint of illuminating power, to say nothing of the additional æsthetic value of a light which approaches sunlight in whiteness, each unit of it must be regarded as the equivalent of rather more than 1.25 units of gas light.

The character of the light corresponds to a temperature much above that of the electric arc, but the flame does not seem to be very hot. I have not as yet succeeded in obtaining a satisfactory measurement of the flame temperature, but a preliminary test, made at my request, gave approximately 1,400°C. This value, which is presented subject to correction, enables us to classify the magnesium flame, at least placing it among those the temperature of which is far below the melting point of platinum. "Its temperature, probably, does not differ widely from that of the luminous gas flame.†

The large candle-power of the magnesium flame is due to its peculiar structure. A gas flame consists of a column of heated gases, the particles of which are rising rapidly from the jet of the burner. These carry off with them, by convection, 80 per cent. or more, of the heat of combustion. The flame owes its luminosity entirely to the fact that near the base of the column a few particles of carbon, as yet unoxidized, are heated to incandescence. The total radiating surface of these particles is very insignificant, compared with the apparent superficial area of the flame; it is, indeed, not very different in extent from the radiating surface of the filament of an ordinary incandescent lamp of the same candle-power. The constitution of the magnesium flame is very different. The product of combustion is the oxide of magnesium, a white, amorphous solid of considerable density; it is, indeed, fully twice as heavy as the metal itself. The oxide remains, for the most part, in the place where it was first formed. It becomes intensely incandescent, and having large radiating surface, it affords a large amount of light. Under such conditions, convection plays a minor part, and that which is the chief source of loss in the production of light by direct combustion of gaseous fuels is avoided. The gross efficiency is, therefore, very large.

The question of the *character* of the radiation from the magnesium flame offers greater difficulties. It is certain that neither platinum nor carbon at any temperature to which they can be subjected in practice, will give anything approximating to the quality of the magnesium light. I am convinced that we have to do here with a very different law of radiation from that which governs ordinary cases of incandescence. Taking carbon to represent the normal state of affairs, we may say that the radiation of magnesium oxides is out of all proportion to the temperature of incandescence; also that the percentage of those shorter wave lengths, which furnish green, blue and violet light, is abnormally large. That the radiation of the magnesium flame comes in part under the head of what Professor E. Wiedemann has termed "Luminescence," I have little doubt. This word covers all those interesting phenomena known as phosphorescence, fluorescence, etc.

Luminescence is supposed to be due to a different class of molecular vibrations from those which cause ordinary incandescence. One of the characteristics of this class of vibrations is that it tends to produce selective radiation; that is to say, radiation in which a single wave length, or set of wave lengths, predominates. Another characteristic of luminescence is, that it is frequently, perhaps always, the result of previous treatment to which the glowing body has been subjected. This previous process may have been nothing more than the shining of the sun's rays upon the luminescent surface, as in those cases of phospherescence concerning which Becquerel has taught us so much.* It may have been in the course of some chemical reaction or process of crystallization that the body received its preparation. In such cases the power lies latent until it is disengaged by the action of some external force.




The immediate exciting cause may be mechanical, electrical or thermal. In the last case, which most directly concerns us here, a certain rise of temperature is necessary to start the body into luminescence. When this critical temperature is below the red heat the phosphorescent glow attracts attention, and investigation follows. When, however, the temperature of luminescence is high, the effect, however marked it may be, is masked by the ordinary incandescence to be expected at that temperature, and it is overlooked. Luminescence by heat is perforce transient. It is due to the expenditure of energy which has been stored by previous action. If we wish to see the effect repeated we must restore to the material the potential energy which it has lost.

I am not in position to state positively that the glow of magnesium oxide is due to luminescent vibrations, but I am of the opinion that such will be found to be the case. Other metallic oxides, also show peculiarities of radiation which find their explanation most readily under that theory. While studying the distribution of energy in the visible spectrum of the lime-light, three years ago, Mr. Franklin and I found that a freshly ignited cylinder, under the oxy-hydrogen flame, glowed with a brilliancy equal to that of the magnesium light itself.* This state of affairs lasted but a moment, however, and no amount of heating would bring out an old cylinder again into its initial splendor. It was plain that we were taking advantage of vibratory power stored in the lime at some stage in its preparation. These vibrations, disengaged by the blowpipe, gave out in a very short time, after which the performance of the lime degenerated rapidly to the level which corresponds to ordinary radiation at the temperature in question.

You are all acquainted with the beautiful greenish-yellow light which the oxide of zinc emits under the flame of the blowpipe. It is entirely different from the light of the incandescent charcoal on which it lies, although the two cannot differ widely in temperature. The zinc oxide is luminescent, the carbon is simply incandescent, in the usual sense of the word. This is a case which lends itself readily to study, since the temperature at which the abnormal glow appears, is a comparatively moderate one. Last summer I took the matter up, with the efficient co-operation of Mr. B. W. Snow, Instructor in Physics in Cornell University. We made a systematic comparison of the radiation from zinc oxide and from platinum, at temperatures between the red heat and 1,000°C., measuring temperatures and studying spectra by methods which I cannot dwell upon here. Since the results which we obtained are of a character to illustrate the points which seem to me most significant, in this question of the radiation of the metallic oxides, I will indicate them graphically.

Zinc oxide is a rather brilliant white pigment. Its radiating power, therefore, according to the theory of exchanges, should be very small. At temperatures below 700° C. we found it to be very much lower than that from platinum throughout the spectrum, and the light from the oxide to be of a duller red. Fig. 8 shows the results of the comparison. In this and the subsequent curves, platinum is taken as the standard. The curves show how the oxide of zinc compares with platinum in strength of radiation. The law according to which the visible radiation of platinum rises from zero at the extreme red heat, as the temperature rises, varies with the wave length. It had to be especially determined for the purposes of our investigation in each region of the spectrum to which our measurements were extended.

At about 700° a sudden change occurs in the character of the light from the oxide. It becomes brighter than the platinum of the same temperature, the increase showing itself principally at the ends of the spectrum. In Fig. 8 (707° and 739°) we have curves which represent this second phase. The emanations are selective to a marked degree, the yellow being relatively very weak. Measurements of fresh films of the oxide at still higher temperatures revealed the further development of the abnormal radiation of this substance. Fig. 9, which gives curves for 878° and 1,034°, shows the transition into a third, and, apparently, a final stage. The red end of the spectrum loses its prominence, and the curve seems to be developing into a straight line, the trend of which is such as to indicate that zinc oxide, as we pass from the longer to the shorter wave lengths of its spectrum, increases in superiority over platinum at the same temperature.

It soon became evident, from the character of our results, that the radiation at temperatures above about 800° were of a very evanescent sort, falling off in intensity and changing in quality from the first instant in which the oxide was heated. To follow these rapid changes proved a trying task. By taking a great many fresh films of the oxide and watching the time changes of one portion of the spectrum after another, however, we were able to obtain data from which the curves in Fig. 10 were drawn. These show the intensity of radiation and its character, relative again to that of platinum, after the oxide had been maintained at 1,013° for a period of 30 seconds, of 60 seconds, of 300 seconds, and of 600 seconds. At the end of the 10 minutes, the changes, although not entirely completed, were very slow.

The evidence of the existence of luminescence afforded by these measurements, seems to us to be nearly conclusive. Extension of the investigation to other of the metallic oxides and to wider ranges of temperature, would, doubtless, lead to results more striking.

The application of all this to the problem of the light of the future is as follows: The fundamental question is that of efficiency. High efficiency at low temperatures means selected radiation, which appears to be a characteristic of luminescence and not of ordinary incandescence. The study of the radiation of the metallic oxides above the

*J. Thomsen: "*Journal fur Praktische Chemie*, N. F., 16, p. 97.

* Ernest Merritt: *American Journal of Science*, vol. xxxvii, p. 167.

† Rossetti (*Beiblaetter zu den Annalen der Physik*, 2, p. 333), gives as the temperature of the gas flame, 1,340°; of the positive carbon of the arc, at the hottest point, 3,900°; of the negative carbon, 2,450°.

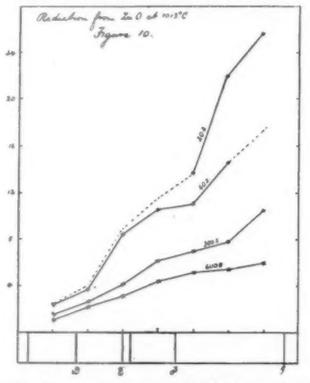
*Becquerel; *Annales de Chimie et de Physique* (3), 55.

* See the *American Journal of Science*; vol. xxxviii, p. 100.

red heat reveals the existence of properties which lead us to regard them as being luminescent "by heat." It is from such bodies that radiation of high efficiency is to be looked for. We have in magnesium oxide a member of this particular class, and we have seen that when it is heated in the process of formation it gives us a light the efficiency of which is unapproached by that of other artificial illuminants.

The problem is easily stated. (1) We need a body which is rendered vividly luminescent by heat.—The metallic oxides would seem to offer us many such. (2) The material is to be brought to the temperature at which its luminescence is most marked.—Does it not seem probable that the best method, as in the case of carbon, will not be that of direct combustion, but of heating through the agency of the electric current? (3) The material must be restored from time to time.—Whether rejuvenation is to be secured through electrical, chemical, actinic or mechanical means remains to be determined.

Luminescence "by heat" offers, however, only a partial solution of the problem of the highest efficiency. However great the efficiency of the luminescent itself, it is accompanied by incandescence of the ordinary kind. The ultimate solution is to be sought for along other lines. Incandescence is too expensive a means of exciting luminescence. There are many other ways in which it may be generated; friction, chemical action, the impact of light waves, electrical excitation, certain vital processes, are known to result in the production of light. The physics of these phenomena is, for the most part, undeveloped. I know of but two attempts to determine the efficiency of this "light without heat," as it has sometimes been called. The intensity is, as a rule, very small, and the heat has doubtless been regarded as quite below the range of even our most sensitive apparatus. One of these two cases is of especial interest to the electrician. It is that of the spark discharge in vacuo. Professor S. P. Langley and Mr. F. W. Very, in a recent remarkable paper, entitled,




"The Cheapest Form of Light," speak of the heat generated in the Geissler tube as so minute as to seem to defy direct investigation. It has, however, been successfully measured by Dr. Staub, of the University of Zurich, by means of one of the most delicate instruments for the measurement of heat—the Bunsen ice calorimeter.*

In Staub's experiments the vacuum tube was smoked with lampblack and inserted in the ice calorimeter. The ice melted in a given time afforded a measure of the total heat generated by the electric discharge through the tube. A repetition of the determination with the unsmoked tube, under which conditions the light-giving rays could escape, gave the energy of the non-luminous radiation. The efficiency was found to be 3.268 per cent. The extremely small candle-power of the light derived from the electric discharge in vacuo, may seem to preclude all questions of its utilization in practical illumination. The result is one, however, which should not be lost sight of. It suggests a field of investigation which may prove unexpectedly fruitful.

The Geissler tube effect was not the source to which Langley and Very applied the term "the cheapest form of light." The subject of their research was the light of a Cuban fire-fly. Their work cannot fail to excite the highest admiration of every one who is able to appreciate the difficulties of such an investigation. The exploration of the heat spectrum of so insignificant a source of light is a task which very few physicists would, I think, have considered practicable, but it has been carried through by these investigators to complete success.

When we study the curve of distribution of energy in the spectrum of the fire-fly thus obtained, and compare it with the corresponding curves for gas light, the arc light and sunlight, we find the expression, "the cheapest form of light," which is applied to the light of the fire-fly by Langley and Very, to be fully justified. All the energy of its spectrum is massed within the narrow limits of the visible spectrum, and what is more, by far the greatest part of it is in the form of rays which are especially important for the purposes of radiation, the particular rays which give us yellow and green light. The non-luminous radiation which accompanies the light of the fire-fly seems to be so insignificant that it was with difficulty that it could be estimated, even with the almost inconceivably delicate apparatus used by Langley and Very. They give the efficiency as about 400 times as great as that of a gas flame. It cannot fall appreciably below 100 per cent.

In what I have said this evening, I fear that I have fallen far short of what might have been expected of a lecturer on the artificial light of the future. I have endeavored to show that the efficiency of our present methods is too low to meet the demands of the future for economical illumination, and that whether we ever succeed in approaching the perfect economy of nature's light-making processes, as exemplified in the fire-fly, or not, there are many sources of light which promise high efficiency. If I have succeeded in indicating, even vaguely, some of the conditions of the problem of the utilization of these, and in pointing out some of the lines of investigation which are to be followed in the development of new methods of lighting, my mission has been fulfilled.

THE DISCUSSION.

The Chairman: Gentlemen, I feel sure that I am expressing the unanimous sentiment of the Club in tendering to Professor Nichols our hearty thanks for his brilliant and luminous lecture. Are there any remarks on the subject?

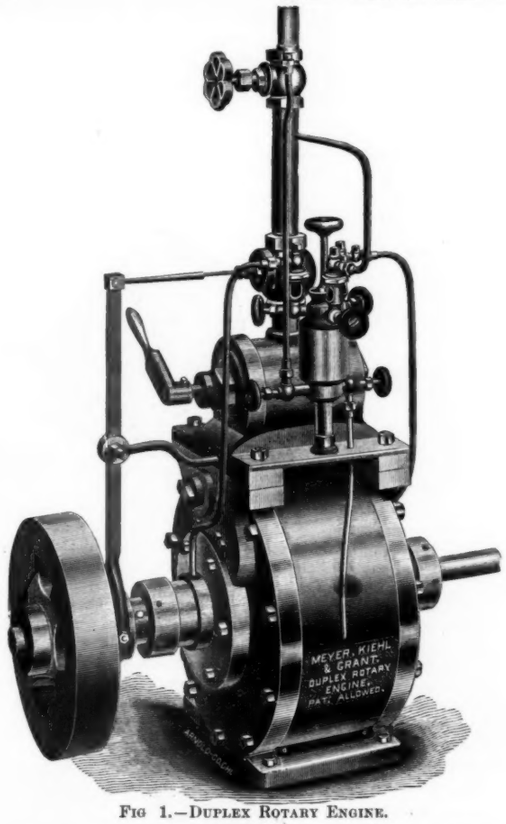



FIG 1.—DUPLEX ROTARY ENGINE.

Dr. Otto A. Moses: I feel that every one will agree with me that we have all been instructed by Professor Nichols' admirable lecture. He has given us a great many sweet morsels to roll under our tongues when we go home. There is one very pregnant point that Professor Nichols has called our attention to—an original observation of his own—where he speaks of there being, perhaps, a storing of energy necessary before light can be produced. In the beginning of this century, one of the Shakers invented what has since been known as the Reece fusing disk. I believe it was patented some 20 years ago by Mr. Reece. It was described in *Silliman's Journal* in the beginning of the century. It is a most wonderful thing to see a disk of soft iron revolving at an enormous peripheral speed, cutting through cold iron or steel. There is very little heat produced and an abundance of light from the innumerable sparks that are drawn off from the cold metal, so the observation that an energy potential must exist before there can be any change into light is, I think, there demonstrated. There was a vast peripheral velocity necessary, not actually in the form of work being done, but it was potential. We know that in the very act of phosphorescence there is a storing of energy that was produced from light—very little of it from heat. The sun goes down and our fluorescent material shines hours afterwards, so that there is the closest connection between energy stored and subsequent luminescence.

Mr. Wetzler: Professor Nichols has given us examples of a number of methods in which illumination can be produced electrically, but it seems to me that one method has been omitted, and that is one in which illumination is produced by the continuous disruptive discharge produced by the spark of an induction coil, a method which is sometimes employed in the laboratory.

Professor Nichols: I do not know of any efficiency measurements excepting those which I have tried to give you some account of to-night. It is a subject which has not been worked up, so far as I know, except this case of the spark discharged in vacuo and in rarified gases by Professor Staub and in Mr. Langley's work upon the fire-fly and in the well known work that has been done recently by various observers concerning gas and oil and candles and the electric light.

Mr. Tesla: We know the beauty of the magnesium light and it occurred to me several years ago that it might be practical to utilize it. But we must, if we utilize the magnesium light, utilize the magnesium in such a manner that it is spread over a great surface something like in the Geissler tube. Chloride of magnesia dissolves in water, and I mixed it with carbon powder and distributed this paste over the whole mass of the carbon. When the carbon is heated the magnesia is decomposed and the chloride goes away. The arc light then gave this magnesia effect. I have also in this manner produced incandescent carbon filaments. I produced lamps which gave a remarkably nice white light. Professor Nichols also mentioned, I believe, that the flames when they are subjected to a good draught diminish in luminosity. I think it is pretty safe to say that in all cases where we can keep away chemical association or a disintegration that as we raise the temperature the body gains steadily in luminosity and it is only due to a chemical process when we send a draught through the flame that the luminosity is diminished. If the carbon can be prevented from breaking then we may avail ourselves of the advantages we gain at the higher degrees of incandescence. This is a point on which I am not now able to speak, but I have made some experiments in that direction. It is a different plan of work, and at some time or other I may be able to bring it before you.

After some further discussion, a vote of thanks was unanimously tendered Professor Nichols, and the Club adjourned.

### The Duplex Rotary Engine.

A late design of rotary engine is shown in the accompanying illustrations. In construction it is different from other engines of its class. Its makers claim for it great economy in steam and wearing capacity. It is practically a straight line engine with a rotary movement, having an expansion cut-off; the amount of steam used expansively is gauged by the position and length of the ports; no valves or mechanical contrivances being used for that purpose. The wheel or disk in its motion operates as an automatic cut-off in passing one port over another.

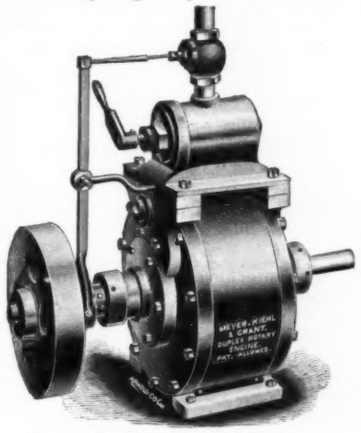



FIG. 3.—DUPLEX ROTARY ENGINE.—SMALLER SIZE.

The working parts are confined to four pistons or levers operated by an eccentric within the engine, and so arranged that their wear from friction is reduced to a minimum. When service may render it necessary, their replacement is easy and the cost trifling. Another feature which makes it an economical engine is that its motion being continuous and steady, the vibration being hardly discernable when revolving at high speed, renders it unnecessary to construct any special foundation, even for engines of the largest make, while the floor space required is of very small area.

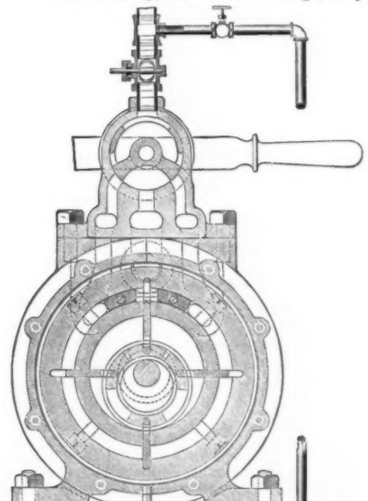


FIG. 2.—CROSS SECTION OF DUPLEX ROTARY ENGINE.

Although a high rate of speed is attainable by the use of a sensitive governor, any motion desired can be obtained; and by the operation of the rotary valve, the movement can be easily and quickly reversed, without the slightest injury to any of its parts. The engine is especially adapted for direct coupling to dynamos. The Duplex Rotary Engine Company, 70 and 72 La Salle street, Chicago, builds these engines.

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Incandescent lights are being put in the city hall, at Salt Lake City, Utah, and the building will soon be lighted by electricity.

* G. Staub: Inaugural Dissertation, Zurich, 1890. (See the *Beiblaetter zu den Annalen der Physik*, 14; p. 538.)

## KINDRED INTERESTS

**The Eureka Tempered Copper Company,** North East, Penn., are mailing to their friends a little circular describing the merits and uses of their fine tempered copper products.

**The Fort Wayne Electric Company,** Fort Wayne, Ind., has just closed a contract, through Mr. C. S. Knight, for 720 2,000 candle-power arc lights of the Wood system, to go to the Louisville Gas Company, Louisville, Ky.

**The Markle Engineering Company,** Detroit, have recently issued a circular describing the Stoddard non-combustible rosette cut-out, for which high claims are made. Other of their specialties are described in the same circular.

**The Southern Electrical Supply Company,** St. Louis, in connection with their agency for the sale of Okonite wire, have recently accepted the agency for the Connecticut motors. This is a good firm and a good motor; the sales ought to be good.

**The Fitchburg Engine Company,** Fitchburg, Mass., have just put in an entire steam plant for the new gun shop at Waterville, N. Y., consisting of a 250 horse-power duplex engine, three horizontal tubular steel boilers, feed water heaters, pump, etc.

**The Short Electric Railway Company,** Cleveland, O., is out with a beautiful new catalogue. The cover is done in bronze with raised decorations. The Short system is fully illustrated and described. Dr. O. W. Holmes' poem, "The Broomstick Train," occupies the last inside page.

**The Sebastian-May Company,** now of Cincinnati, will be located after December 1 in an elegant new plant just finished by them at Sidney, Ohio. This is the third enlargement of their facilities within the past seven years. The company manufactures drill presses and fine machinery, making a specialty of lathes.

**James W. Queen & Company,** Philadelphia, have sent forth a tasteful two-color leaflet describing the Ayrton & Perry ammeters and voltmeters, for which they are the sole agents in this country. The leaflet is issued as a special announcement to electrical engineers and superintendents of central stations, isolated plants and electric railways.

**T. C. Alcott & Son,** Mount Holly, N. J., have recently shipped two of their 30-inch water wheels, mounted horizontally, to the Red Bank Mills, Lexington, S. C., one 125 horse-power turbine water wheel to the Buchanan Electric Light Company, Buchanan, Va., and two 27-inch turbine water wheels to the Giant's Causeway Electric Tramway Company, Port Rush, Ireland.

**The Mount Washington Glass Company,** of New Bedford, Mass., are adding a story to the main building of their plant, and building a new decorating shop, 125x30 feet. New furnaces have recently been built and adapted to the burning of crude oil in place of coal. These are working successfully, so that this company is now practically on the same basis as those using natural gas.

**H. H. Humphrey,** contracting and consulting electrical engineer, Omaha, Neb., is at present engaged in installing a 100 light electric plant for the Carter White Lead Company in their new works at East Omaha. A United States automatic dynamo will furnish current. It will be driven by an Evans friction device directly from the engine. Bishop white core wire will be used throughout the building.

**The Valley Iron Works,** of Williamsport, Pa., are building a large plant for the manufacture of steam engines at Lynchburg, Va. It is expected that it will be finished by March 1 next, when the whole business of the Valley Iron Works will be transferred to that point. Their manufacturing capacity will be greatly increased by this removal. Orders are in hand for several Valley engines to be used in driving electric plants in Montana mines. These engines are to be in continuous service, 24 hours each day. A 40 horse-power engine has been ordered of the Valley Iron Works by Samuel J. Shriver & Son, of Milton, Pa., for use in an electric plant.

**The Crocker-Wheeler Motor Company,** 430 and 432 West Fourteenth street, this city, have just secured additional space in the building they occupy, and will immediately install new machinery which will about double their manufacturing capacity. The company has recently sold a large number of electric pumps, two installations being in the Calumet Club and the new house of the Reform Club in this city. A new fireproof rheostat is now being made; the frame is of cast-iron and the front slate. The frame is entirely open, allowing free air circulation. Mr. Elias Ries, of Baltimore, has just ordered a five horse-power Crocker-Wheeler dynamo. The armature is to run at 700 revolutions, and the machine is to deliver five horse-power of current at this speed. The dynamo will be coupled direct to a Brotherhood engine.

**The Evans Friction Cone Company,** of Boston, have recently received the contracts to drive with their system of friction the following plants: Lebanon, N. H., Electric Light & Power Co., one 650 light alternator; W. S. Griffith & Co., Philadelphia, Pa., two 200 light Mather dynamos; Washington, Pa., Electric Light Co., one 500 light alternator; Hopedale, Mass., Electric Car Co., two 30 horse-power generators; National Transit Co., Oil City, Pa., one 140 light dynamo; Rhodes Manufacturing Co., Philadelphia, Pa., two 30 light dynamos; A. M. Church Co., Troy, N. Y., one 20 arc light and one 50 light incandescent; Clinton, Mass., Gas Light Co. two 45 arc light, two 650 light alternators and one 30 horse power generator; Worcester, Mass., Polytechnic Institute, one 500 light alternator and one 450 light incandescent; Edison General Electric Co., Broad street, New York, one 180 light dynamo; Belfast, Me., Electric Light Co., one 500 light alternator and one 300 light alternator; P. H. Glatfelter, Spring Forge, Pa., one 400 light incandescent and one 20 full arc; Seamless Rubber Co., New Haven, Conn., one 100 light dynamo; making in all, with the older plants, nearly 4,000 horse-power.

### Thomson-Houston Statement.

The statement of the Thomson-Houston Electric Company for the first nine months of the fiscal year shows: Earnings, $7,514,520, an increase of $2,266,895 over last year; profits after expenses, $1,631,715, an increase of $656,452. Net profits for 1889 were over $2,500,000, from which $1,300,000 was carried to surplus account, after dividing among stockholders $2,400,000 series D securities, which cost the company something more than $1,250,000.

It is also stated that the last three months of the fiscal year are the largest and most profitable of the whole year.

The Royal Electric Company, of Montreal, Canada, has just installed an electric plant for the city of Three Rivers, Mich. There are 80 arc and 2,500 incandescent lights. The plant was set up in very short order, and is a credit to the Royal Company.

### A New Ammeter.

Our illustration shows one of several types of ammeter, handled by the Standard Electric Supply Company, of Boston. It is a high grade instrument, accurate and well-finished. The instruments are tested before leaving the factory, and a guarantee of correctness accompanies each one. It was desired by the makers to offer a good instrument at a low price; this is the instrument they offer.

The readings are direct and dead beat. The range is from a tenth of a volt or ampere up

to the heavy readings required by an instrument for railway work.

These instruments have been on the market long enough to create a considerable demand for them.

### New Ceiling Cut-Out.

We illustrate on this page a new ceiling cut-out which embodies several improvements. It is manufactured by the Star

Electrix Company, of Philadelphia, who are handling it together with their other specialties.

This is one of the neatest and best designed ceiling cut-outs which has appeared up to date The main wires are screwed just 2½ inches apart which avoids bending the wires at the cut-out. It is easily wired, yet there are no bungling screws or castings

on the side to disfigure it. The cut-out is said to be meeting with great favor already with supply men and contractors.

Mayor Hart, of Boston, has named B. S. Flanders to be that city's inspector of electric wires. The appointment is the first under the new statute and city ordinance providing for the official supervision and control of all wires used for the transmission of electric currents. Mr. Flanders is a veteran fireman, and is superintendent of the Boston fire alarm telegraph system.

### Appealing for Jugigo.

The case of the Japanese, Shibuya Jugigo, who is confined in Sing Sing prison under sentence of death by means of electricity, was argued before the United States Supreme Court at Washington, D. C., on November 21. The case went there on appeal from a decision of the United States Circuit Court for the Southern District of New York, declining to grant the writ of *habeas corpus*, which counsel for Jugigo had sought to obtain, to compel Warden Brush to release the prisoner. The question at issue was the validity of the New York law.

Roger M. Sherman, who was counsel for Kemmler, and who now represents Jugigo, based his application for a writ of *habeas corpus* on the ground that the execution of Kemmler demonstrated that electricity was not an instantaneous and painless method of death, and that, therefore, the New York law violates the provision of the Federal Constitution forbidding "cruel and unusual punishment," and is for that reason unconstitutional and void.

Mr. Sherman opened the argument with the assertion that "this gradual burning at the wire instead of the stake," is a refinement upon all cruelty which has ever been devised.

Justice Field: Is there any question that electricity, if sufficiently intense, if kept up without interruption, will produce practically instantaneous death?

Mr. Sherman: On the contrary, there is grave reason to doubt whether artificial electricity, generated under present scientific conditions, will invariably cause immediate death, and we cite the Kemmler case.

Justice Brewer; As a matter of fact, was not Kemmler dead in about four and a half minutes?

Justice Field: It has got to be a fact that electricity sufficiently strong to produce instant death cannot be secured to bring the case here. In hanging, bad machinery, too light weights, a bad rope, may cause torture—that is a mere bungling execution of the law.

Mr. Sherman: This case is different, I think. If I should come here and say the rope is rotten, your Honor would say, "We must presume the State will provide a strong rope." But here is a new and peculiar mode of killing a man by a force which is governed by patents. Now, owners of these patents do not want the sale of their inventions restricted by the use of them in this manner. The State is not in the position of merely having to buy a strong rope It may be the patents will expire some years hence, and the State can then go into the business of making dynamos. But it seems to me sufficient now to show that the only apparatus the State has got, and which it applied to Kemmler, has turned out to be insufficient for the purpose, and violates the statute.

Mr. Sherman closed with the statement that it seemed to him a new condition was presented as to the constitutionality of the State statute, and that unless it was to be assumed, against counsel's offered proof, that electricity would do what Kemmler's case proved it will not do, the court must direct the issuance of the writ.

Attorney-General Tabor followed in a brief address in behalf of the State. As he understood it, either hanging or electricity had too much cruelty in it to suit counsel. He declared that the State, on the trial of the Kemmler case and in the practical execution of the law, had settled the whole question of the constitutionality of the statute. At first the State had been told it could not kill a man by electricity, and then that it could not do so without causing such pain as to make the statute in conflict with the Constitution. The Kemmler execution has vindicated the humane men who framed the law, and the only difference between this case and that of Kemmler was that counsel now wanted to prove what the court would not take notice of then, and in addition to prove, if possible, that the actual execution had shown exactly what he wanted to prove then. He concluded by asking a speedy termination of the case.

LATER.—The Supreme Court decided, on November 24, that Jugigo must die by electricity.

### London and Paris Telephone Line.

Such satisfactory progress has been made at the English end of the London and Paris telephone line that it is now stated that communication will probably be opened by New Year's Day. The cable route has been slightly changed, so that now it is intended to land the English end at St. Margaret's Bay instead of at Hythe. Here it will be connected with a special wire to London, running by way of Dover, Folkestone, Ashford and Maidstone.

## Low Speed Multipolar Dynamos and Motors for Continuous Currents.

BY FRANK A. PERRET.

The many practical advantages of a lower rate of speed in dynamo electric machinery have long been recognized, yet, until recently, few attempts have been made to secure it. The widespread use of the electric motor has, however, rendered low speed a feature of great importance, in that it so greatly simplifies the application of the machine to all classes of work, in most cases obviating the necessity of countershafting or similar speed-reducing mechanism.

The writer is aware of a prevailing opinion that serious difficulties are encountered in the attempts to manufacture this class of machines on a commercial basis, but believing the difficulties to be surmountable, he devoted several years to a careful study of the subject, with the result that he designed a type of machine in which he believes the desired end is attained without the introduction of any element of danger, or the sacrifice of a single feature essential to a thoroughly practical machine. In the light of this experience, it is proposed to consider briefly some of the principles which govern the action of multipolar machines, and to demonstrate that the obstacles which have heretofore stood in the way of low speed may be and have been overcome.

The prime function of an armature conductor is the generation of an electromotive force, the value of which is proportionate to the number of magnetic lines of force cut by it in a given time. Now the number of lines cut per second is dependent upon two factors, (1) the total number of lines of force in the magnetic circuit; and (2) the number of times they are cut per second. As our aim is to generate a given E. M. F. at a *lower* speed than is usual, it is evident that the quantities in either or both of the above factors must be increased. In the case of the first, we are limited by the saturation point of iron, which prevents our indefinitely increasing the strength of the magnetic circuit without adding abnormally to the weight and size of the machine, and, even were it possible to do this, an increased exciting current would be required, which would detract directly from the total efficiency. We turn, then, to the second factor, and, paradoxical as it appears at first, it is here we find the solution of the problem. How are we to cause an armature conductor to cut a given number of lines of force a greater number of times per second without increasing the speed? In the ordinary two pole machine, the armature conductor crosses the magnetic circuit and cuts all the lines of force twice during a complete revolution, viz., where they enter the armature core at one pole and where they leave it at the other. Now, if we so dispose the magnetic circuit as to cause the lines of force to enter the armature core at one point, to leave it at another, to *enter it again at a third point and to leave it a fourth*, it is obvious that the conductor will cut all the lines at four points in each revolution, and that it will therefore generate the same E. M. F. at one-half the original speed. If we increase the number of poles to six, we shall obtain the same effect at one-third the speed, etc., etc. This, then, is the principle of construction by which we secure low speed.

It should be noted that we do not increase the number of lines of force in the magnetic circuit, we do not add to the turns of wire in series on the armature, we do not increase the amount of either copper or iron in the entire machine, but we simply cause the armature conductor to cross the magnetic circuit as often in one revolution as it ordinarily does in two or three revolutions, as the case may be. The writer wishes to emphasize these points as there seems to be some misunderstanding in regard to them. We do not *wind an armature to run slowly*, but we design the machine for low speed. The resistance of our armature is no higher than that of a high speed machine of the same power, its current capacity is not reduced, in fact, as we shall see later, it is increased. The efficiency is no lower, the regulation no less perfect and the weight and bulk no greater. We see, then, that in theory the multipolar machine is perfect, consequently if any difficulties have been encountered in its practical operation they must be due to some faults of construction, to a consideration of which the attention of the reader is now invited.

If we take as an example a motor having a six pole field, and imagine the same in action we see that the distribution of potential is such as to form the equivalent of three ordinary armature windings on the one ring and connected to the commutator, which has three times as many segments as that of a two pole machine. Each of these windings, *i. e.*, the wire lying under one pair of poles, has exactly the same number of turns as an armature of a two pole machine but of smaller wire, and carries but one-third of the total current, the three acting together in multiple. This being the case, any relative difference in the strength of the field magnet poles will cause an unequal distribution of potential and current in the armature. This is, in my opinion, the most important point to be considered in the designing of such machines, as any inequality is sure to cause trouble.

In a bi-polar machine there is but one path for the lines of force, which circumstance insures equal poles; but in the multipolar type, as ordinarily constructed, a variation in the magnetic conductivity of any part of the circuit will cause an inequality.

Fig. 1 represents a form commonly given to multipolar fields. It will be seen that an internal blow hole or hard spot or other imperfection in the casting at A would choke some of the lines proceeding from B, and they would, therefore, flow through C and cause a difference in the strength of the poles. Cast iron should, therefore, be excluded from the magnetic circuit, there should be no joints and the number of magnetizing coils should be as small as possible.

Fig. 2 is a diagram of the magnetic circuit of the machine designed by the writer. In this construction there are but three magnets, each being isolated magnetically from the others, excepting through the medium of the armature core, and completely isolated from the frame-work of the machine. They are formed of plates of soft sheet-iron, which are punched to the required shape and strung together on non-magnetic bolts, by which they are secured to their supports. A single magnetizing coil forms two salient poles, and as each magnet is built of a large number of plates, a uniform magnetic conductivity is secured. By this method of construction all danger of any inequality in the strength of the poles is avoided and a magnetic circuit without joints and of the lowest possible resistance is secured. It is understood, of course, that in all cases the number of ampere turns on each magnet must be equal.

In proportion as we decrease the "feet per minute" we increase the "pounds raised," or, in other words, the mechanical effort or torque is greater in a low speed than in a high speed machine. Extra pains should, therefore, be taken to secure a substantial mechanical mounting for the armature upon the shaft, and also for the wires upon the core. The armature is, therefore, built upon eight insulated steel bolts, the ends of which are secured to non-magnetic spiders, which, in turn, are keyed to the shaft. The wires are wound in longitudinal channels on the periphery of the armature core which holds the coils rigidly in place and entirely prevents that minute shifting of the wires which certainly is the cause of so many "break-downs" and "burn-outs" in armatures. The driving force in a motor and the resisting force in a dynamo is exerted by the armature conductors, and we should always provide a positive mechanical connection between them and the core; friction does not suffice. The importance of this point is fully understood by Kapp, who writes: "In many machines the friction produced by the binding-hoops is alone relied on to carry the wires through the field; but experience has shown this to be insufficient. Even if the wires are not bodily torn off the armature by the magnetic resistance of the field, they shift and work on the surface of the core; and it is only a question of time when the insulation will be destroyed and the machine break down."

We have a choice of two methods of coupling the armature circuits together in multiple, one of which is by the use of six brushes distributed around the commutator 60 degrees apart—three negative and three positive—and the other consists of a system of cross connections in the armature or commutator which connects those coils which are simultaneously undergoing the same induction; these in a six pole machine are situated 120 degrees apart. By this means a single pair of brushes suffices, and these bear on the commutator at points diametrically opposite, exactly as in a two pole machine. This method is preferred when copper brushes are used, and I have in use a simple system of cross connections at the back of the commutator, in which all danger of short circuiting is avoided; but the carbon brush is so peculiarly adapted to the method first described that it forms one of the simplest and most reliable means of commutation that can be devised. The high resistance of the carbon brush, as ordinarily constructed, has prevented its universal adoption, but the construction of this machine permits the use of three pairs of brushes, each pair carrying but one-third of the total current, and the resistance is greatly reduced by reason of the increased contact surface.

In a two pole machine the armature current is divided equally between two circuits, while that of a six pole machine splits into six. This the writer considers in most cases an advantage, as the current carrying capacity is increased by reason of the greater surface exposed to radiation, and the machine will consequently bear a greater overload without injury while the wire is not so large as to be unmanageable. In many machines of the two pole type a stranded armature conductor must be used because a single wire would be too stiff and would heat too much; in a multipolar machine these troubles are avoided.

A great deal has been said and written in respect to the difference of potential that should be allowed to exist between adjacent commutator segments, some writers having advanced erroneous opinions on this point to the disparagement of multipolar machines. One tells us that 10 volts should be the limit, because "10 volts will just form an arc," while another puts the limit at 19 volts and gives the same reason. Now, an arc has to be started or "drawn," and the only time this can happen is when the brush connects two adjacent bars as they pass under it. But this only takes place at the so-called neutral points, where the difference of potential between adjacent bars is almost nothing.

Theoretically, this difference of potential is simply the product of half the total current and the resistance of the coil connected to the two bars. We see, therefore, that we should not take for a basis of calculation the *average* difference of potential between adjacent bars, for the reason that the E. M. F. of each coil is continually varying from zero to maximum and down to zero again. A very clear description of this action will be found in the fourth chapter of S. P. Thompson's "Dynamo Electric Machinery," together with the methods used in determining it, and I commend a perusal of this to the writers referred to.

In a machine wound for 220 volts and having 22 coils acting in series, we do not find a uniform difference of potential of ten volts between adjacent commutator bars, but those coils which are passing the poles are generating 15 or 20 volts, while those in the neutral zone are generating practically nothing. In some of the most widely used closed coil machines in this country the average difference of potential between adjacent segments is far greater than the limits given by the above mentioned writers. In one of these it is 27 volts, in another 50 volts, and in others it is still higher, yet these machines give no trouble whatever. Let me not be understood to favor the use of a small number of commutator sections, I simply wish to show that no one is limited to ten or 19 volts average potential difference between adjacent bars.

In the machines of my own design, which I have partially described, the number of sections in the commutator is 96, of which 16 act in series. At an E. M. F. of 220 volts they average, therefore, 13¾ volts each, and at 500 volts total E. M. F. they will average 31¼ volts.

As bearing upon some of the statements which I have made, I present the following details of my 10 and 20 horse-power machines, which fairly represent them all:

Ten horse-power 220 volt motor: Speed, 600 revolutions per minute; weight, 900 lbs.; resistance of armature, .19 ohms; resistance of shunt, 175 ohms.

Twenty horse-power 110 volt dynamo (compound): Speed, 600 revolutions per minute; weight, 1,800 lbs.; resistance of armature, .029 ohms; resistance of shunt, 26 ohms; resistance of series coil, .007 ohms.

It will be seen that a low speed multipolar machine is not necessarily a heavy one, but that, on the contrary, it may be made very light. The writer has recently built several 25 horse-power series wound motors, which weighed 1,300 pounds each, and ran at a speed of 500 revolutions per minute. If one of these were so wound as to run at 1,000 revolutions per minute, it would develop 50 horse-power, and weigh only 26 pounds per horse-power. For traction purposes, these motors are designed to run as slow as 450 revolutions per minute, and weigh about 70 pounds per horse-power.

In regard to their practical operation, I will simply say that the first machines, which were constructed a year ago, have been in constant and satisfactory use ever since, and they have proved themselves to be in every respect the equals of the high speed machine.

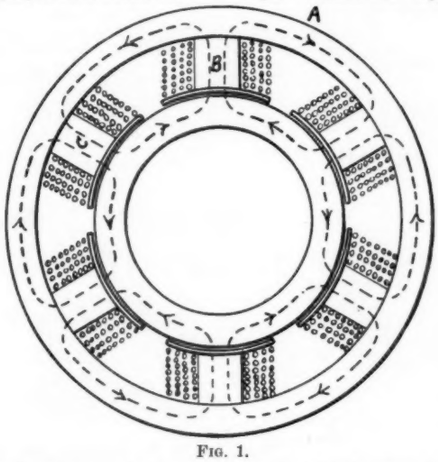


FIG. 1.

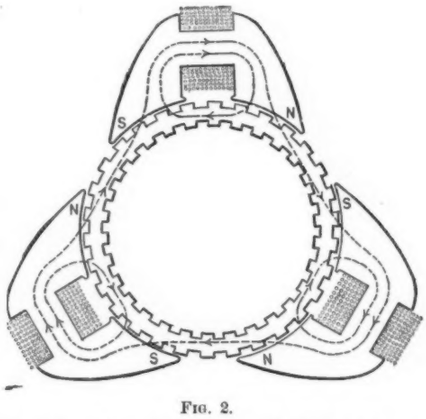


FIG. 2.

### Accumulators at Chelsea, England.

The Accumulator Company, of this city, is in receipt of the following letter, which explains itself:

LONDON, E. C., Oct. 22, 1890.

C. H. Bates, General Manager
Electrical Accumulator Company,
No. 44 Broadway, N. Y.:

DEAR SIR—I have pleasure in informing you that the central station in Chelsea is not only giving every satisfaction to the technical staff, but, what is more important, is being highly appreciated by the consumers in the neighborhood.

The point I presume that will be of most interest to you is the question of the life of the storage batteries in use. These are all of the L 31 type and you will be happy to learn that no renewal either of the positive or negative plates has taken place with any of the batteries, even to the oldest, which was brought into operation about 20 months ago. Very little deposit has accumulated at the bottom of the cells, although some of the batteries have received very heavy work, and we are in hopes that no considerable renewal of positive plates will arise for, at any rate, 18 months or two years.

The method of charging the batteries in series proves to be an exceptionally good one, because every cell is always in the same condition as its neighbor, and this advantage is further accentuated by all the cells of the main batteries being worked to the same extent, and for the purpose of regulating counter electromotive force cells are only employed.

You can rely that I shall have from time to time much pleasure in giving you any information that you may write for, and whenever you or your representatives happen to be in this country it will be my company's best pleasure to show you the station in operation.

In conclusion, I would mention that the original capital required for working an installation on the E. P. S. system is little, if any, more than by any other good system with similar advantages. I am, dear sir,

Faithfully yours,
The Foreign and Colonial Electrical Power Storage Company, Limited.
HUBERT MUSGROVE, Engineer.

The Plainfield, N. J., Gaslight Company is said to have purchased the Plainfield Electric Light Company's plant.

### A Novel Electric Lighting Scheme.

The Hawkeye Electric Manufacturing Company, of Davenport, Iowa, has made a novel proposition to the city council of Davenport. They propose to erect a plant for the furnishing of light in the city, to erect 33 arc lamps on masts or poles, and to place 500 incandescent lamps in the bill districts, and for the operation of this plant for the term of seven years to receive the sum of $1,500 monthly rental, at the end of that time the city to become the possessor of the plant without other expense than the formal payment of $1. The proposition carries with it a condition for exemption from taxation for the time proposed.

### FINANCIAL.

Closing quotations of electric stocks, from F. Z. Maguire & Co., Electrical Securities, 18 Wall street, N. Y., Saturday, November 22, 1890. New York, Boston and Washington Stock Exchanges. Pittsburgh closing November 21, 1890.

| | |
|---|---|
| **NEW YORK.** | |
| Western Union Telegraph Co. | 78½ |
| American Telegraph & Cable | 86 |
| Central and South American | 155. |
| Mexican | 210. |
| Commercial Cable Co. | 100. |
| Postal Telegraph Cable | 39. |
| Edison General Electric Co. | 86½ |
| " " " Deferred | |
| Consolidated Electric Light | |
| Edison Electric Illuminating Co. | |
| United States Electric Light | 30. |
| North American Phonograph | 25. |
| **BOSTON.** | |
| Thomson-Houston Electric Co. | 44. |
| " " " Preferred | 25¾ |
| " " " Series C | |
| " " " Series D | 5¾ |
| " " International Co. | |
| " Welding Co. | 175. |
| " European Welding Co. | |
| Ft. Wayne Electric Co | 10½ |
| **TELEPHONE:** | |
| American Bell | 216. |
| Erie | 47. |
| New England | |
| Mexican | .75 |
| Tropical American | |
| **MISCELLANEOUS:** | |
| Edison Phonograph Doll | 1⅛ |
| **WASHINGTON.** | |
| Pennsylvania Telephone | 25. |
| Chesapeake and Potomac | 66. |
| American Graphophone | 12½ |
| United States Electric Light (Washington) | 130. |
| Eckington and Soldiers' Home Electric Ry. | 58½ |
| Georgetown and Tennallytown | 49. |
| **PITTSBURGH.** | |
| Westinghouse Electric Mfg. Co. | 24½ |


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40c. Bell Hangers' Staples, per lb., 10c.
$1 Leclanche Batteries, 45c.
$1 Carbon Batteries, 40c.
$3.75 Spark Coils, $1.50; $10 Medical Batteries, $3.50.
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*Send for Catalogue 1-66 of Electrical Test Instruments.*
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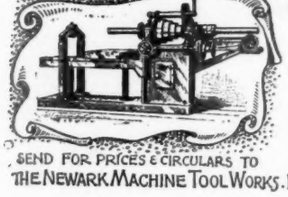

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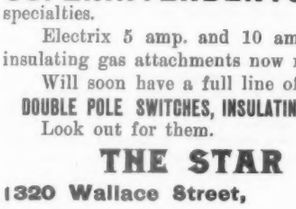
**ELECTRICAL PATENTS**

INDEX OF INVENTIONS FOR WHICH LETTERS PATENTS OF THE UNITED STATES WERE ISSUED ON NOVEMBER 18, 1890.

440,614 Electric switch; Ernest T. Barberie and James Des Brisay, New York, N. Y.
440,627 Electric meter; Sebastian Z. De Ferranti, Hampstead, County of Middlesex, England.
440,640 Electric welding transformer; Hermann Lemp, Lynn, Mass., assignor to the Thomson Electric Welding Co. of Maine.
440,641 Electric welding apparatus; Hermann Lemp, Lynn, Mass.
440,654 Lightning arrester; Edwin W. Rice, Jr., Lynn, Mass.
440,662 440,663 Electric arc lamp; Elihu Thomson and Edwin W. Rice, Lynn, Mass., assignors to the Thomson-Houston Electric Co. of Connecticut.
440,664 Method of electric welding; Elihu Thomson, Lynn, Mass., assignor to the Thomson Electric Welding Co. of Maine.
440,665 Trolley arm for electric railways; Elihu Thomson, Lynn, Mass.
440,682 Burr remover; William M. Wood, Boston, Mass., assignor to the Thomson Electric Welding Co. of Maine.
440,685 Electric cut-out; Geo. H. Alton and Edwin W. Rice, Jr., Lynn, Mass., assignors to the Thomson-Houston Electric Co. of Connecticut.
440,686 Electric railway car motor; Isaac F. Baker, Lynn, Mass., assignor to the Thomson-Houston Electric Co. of Connecticut.
440,689 Electric railway car; Warren I. Belding, Chicago, Ill.
440,691 Electric collecting device or brush; Harold P. Brown, New York, N. Y.
440,699 Electric motor. 440,700 Electric motor and generator; Chas. E. Dressler, New York, N. Y.
440,717 440,718 Electric motor mechanism; Samuel E. Mower, New Haven, Conn., assignor to Henry G. Thompson & Sons, same place.
440,720 Electric switch; Chas. A. Pfluger, Chicago, Ill., assignor to David P. Perry, same place.
440,766 Telegraphy. 440,767 Synchronous telegraphy. 440,768 Multiplex telegraphy; Patrick B. Delany, New York, N. Y.
440,776 Electric motor; Harry B. Pullman, Cambridge, O., assignor of three-fourths to Chas. D. Robbins and Harrison O. Patch, both of Washington, Pa.
440,780 Underground conductor. 440,781 Trolley or plow for electric railways. 441,043 Underground wire system; Edmond Verstraete, St. Louis, Mo., assignor of one-half to Peter M. Kling and Geo. J. Kobusch, same place.
440,789 Overhead conductor for electric railways; Robt. D. Cushing, Boston, Mass.
440,814 Trolley for electric railways; Chas. A. Lieb, New York, N. Y.
440,821 Electric motor; Leo Bock, Jr., New York, N. Y., assignor, by direct and mesne assignments, to himself and Chas. L. Wright, same place.
440,822 Electric conduit; William J. Brewer, New York, N. Y.
440,845 Electric switch; Chas. H. Herrick, Winchester, Mass.
440,881 Signaling apparatus for electric railways; Frank F. Loomis, Akron, O.
440,898 Calling device for clock telephone lines; John A. McManman, Milwaukee, Wis.
440,906 Electric railway; Samuel Trott, Halifax, Can.
440,908 Dynamo-electric machine and motor; Frederick V. Anderson and John O. Girdlestone, London, England.
440,925 Railway signal. 440,926 Railway signaling device. 440,927 Railway signaling system; Joseph W. Riggs, Minneapolis, Minn., assignor to the Riggs Electric Traveling Danger Signal Co., same place.
440,976 System of electrical transmission of power; Chas. J. Van Depoele, Chicago, Ill.
440,977 Generator for pulsating currents; Chas. J. Van Depoele, Lynn, Mass.
441,030 441,033 Train signal for railroads. 441,081 Train signal. 441,082 Railroad gate. 441,084 Lighting railroads; Wm. D. Sheldon, Providence, R. I., assignor to Nicholas Sheldon, same place.
441,044 Electric railway signal; William H. Waddell, Lexington, Va.
441,059 Incandescent electric lamp socket; Jas. W. Collier, New York, N. Y.
441,066 Thermal protector; Hammond V. Hayes, Cambridge, Mass., assignor to the American Bell Telephone Co. of Massachusetts.

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**WITNESS THE FOLLOWING:**

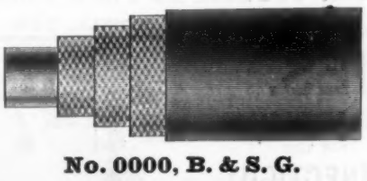
WEST END STREET RAILWAY CO.,
BOSTON, MASS., March 13, 1890.

SIMPLEX ELECTRICAL CO., Boston, Mass.:

*Gentlemen:* In regard to your inquiry concerning my opinion of the Simplex Wires, I would say that during the last year we have used a great many miles of the larger sizes, principally the **0000,** and it has given excellent satisfaction. There has been no case, to my knowledge, of trouble arising from these wires.

The general appearance and workmanship of the wire are first-class, and I consider it equal to any wire, and superior to most wires, for overhead work. Yours truly,

F. S. PEARSON,
*Chief Engineer Steam and Elect. Dept.*



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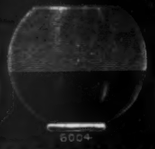
**GLOBES**  **SHADES**

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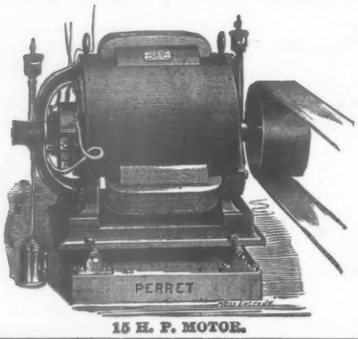


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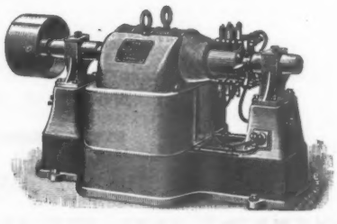

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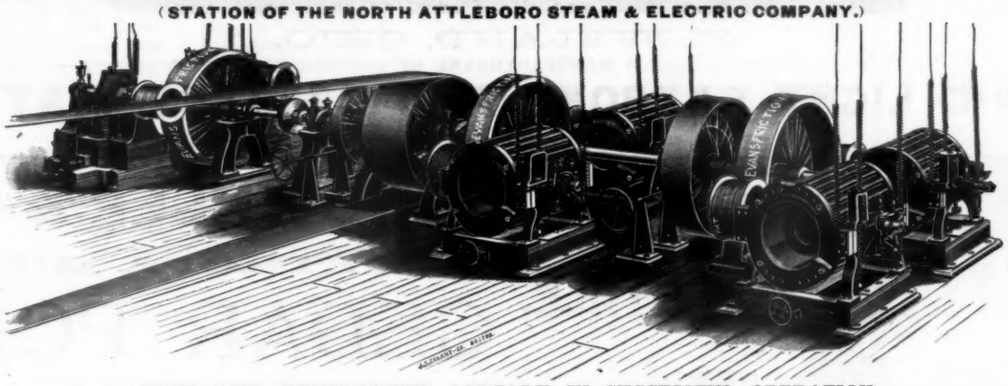

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|---|---|---|---|---|---|---|---|---|
| C | 8 | ..... | ..... | ..... | 6.5 | 1¼ | | 530 |
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| C | ..... | ..... | ..... | 25 | 8.0 | 2 | | 530 |
| D | 16 | ..... | ..... | ..... | 12.0 | 2½ | | 780 |
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|---|---|---|---|---|---|---|---|---|
| H | ..... | 35 | ..... | 45 | 21.0 | 4 | | 1,360 |
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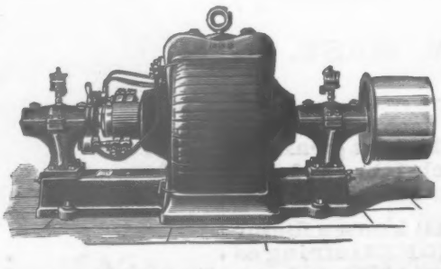

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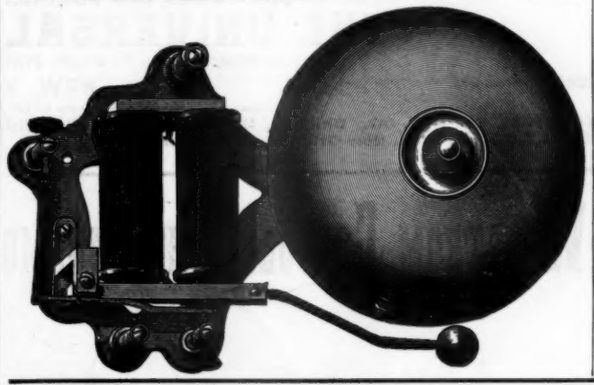

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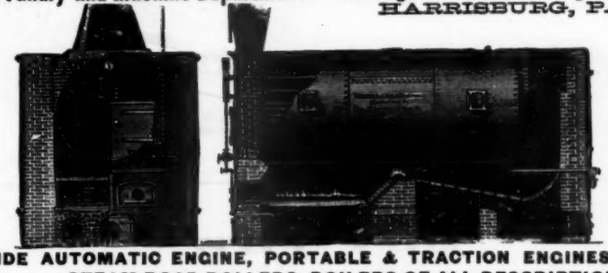

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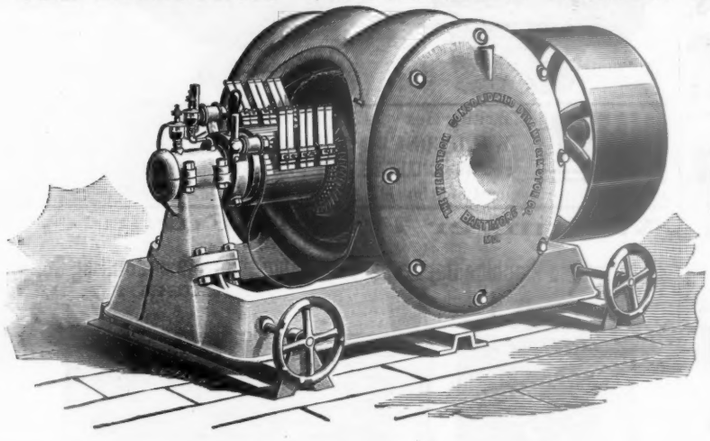

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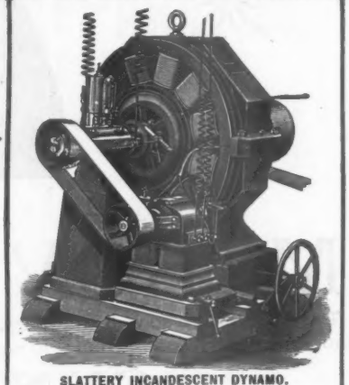

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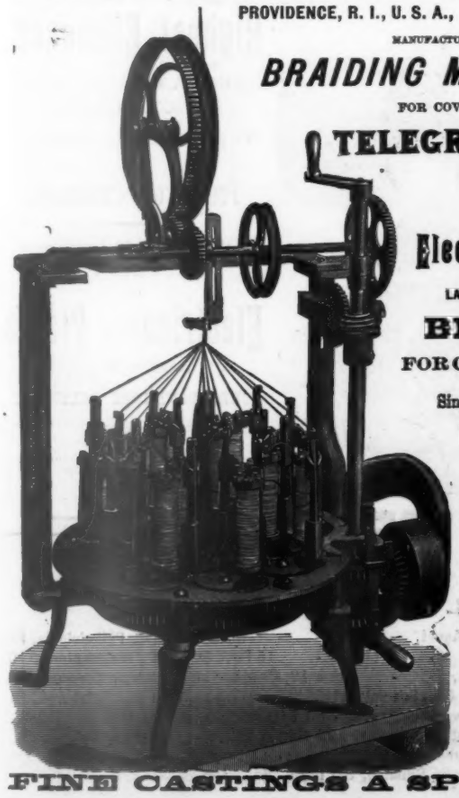

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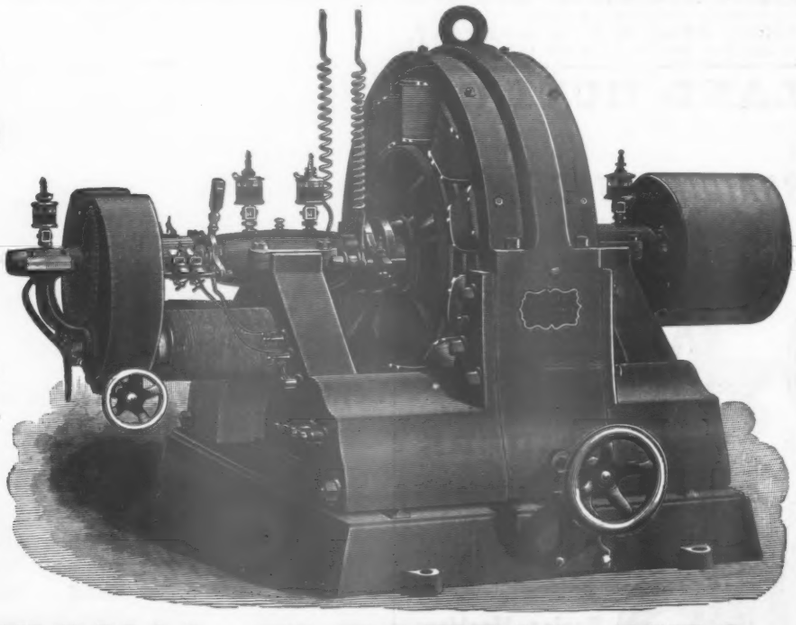

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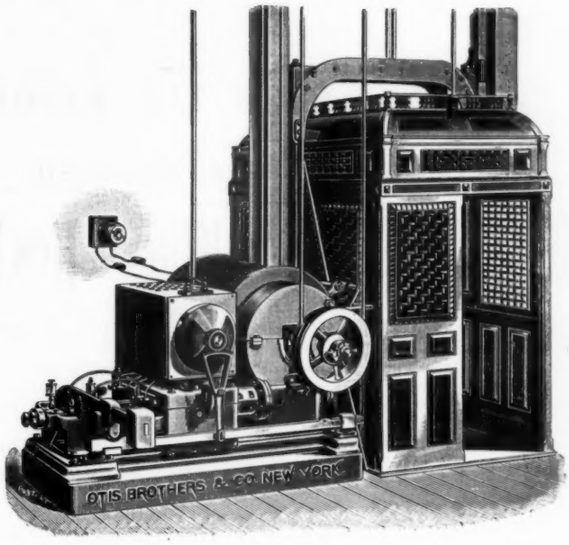


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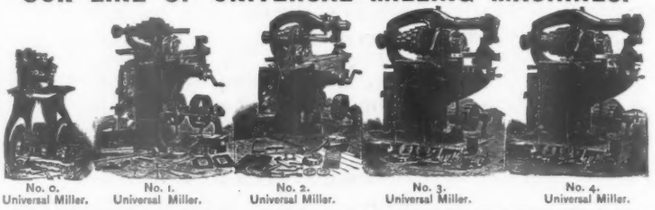

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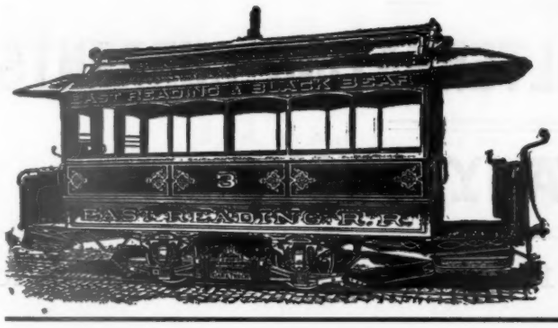

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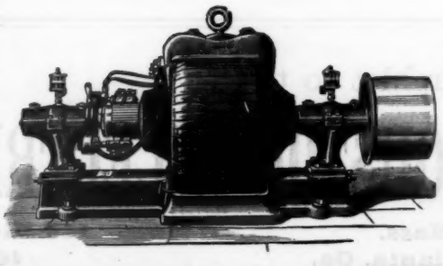

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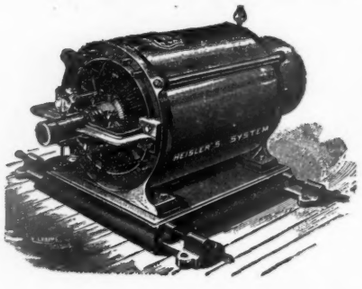

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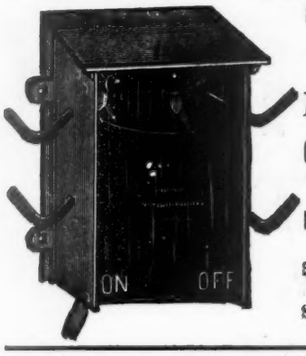


**Nos. 5 & 7 Dey St., New York**

Manufacturers and Importers of and Dealers in

**Telegraph, Telephone**

— AND —

**Electric Light Supplies**

AGENTS FOR

Cleveland Arc Light Cut Outs & Gang Switches

Cleats, Rosettes, Moulding, Pins, Cross-Arms, Brackets. Insulating Tapes.

Rubber, Porcelain and Glass Insulators

WIRES OF ALL KINDS.

Silk & Cotton Covered Flexible Conducting Cord of various sizes for Incandescent Lighting.

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Consulting and Contracting Engineers. Complete Equipment of Electric Street Railways.

STEAM POWER PLANTS. STATION CONSTRUCTION. CONDUITS.

HILL'S

DOUBLE-POLE CONVERTER SWITCH

Opens both Poles of Primary Circuit,

THEREBY AVOIDING ALL DANGER

WHILE WORKING ON THE

*Converter or on the Secondary Circuit.*

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# NATIONAL ELECTRICAL MFG. CO.

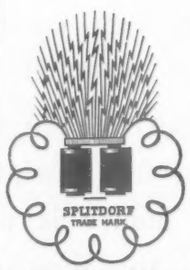
14 & 16 Vesey Street, New York, N. Y.

SUCCESSORS TO

Electrical Dept., New Haven Clock Co., Microphone Carbon Battery Co., Crowdus Dry Battery, Porter Electric Messenger Co., Splitdorf Wire Co.

IF YOU WANT A PERFECT WIRE, USE THE

# SPLITDORF WIRE.




THIS Company owns all of H. SPLITDORF'S CELEBRATED PATENTS for covering all sizes of wire. All wire manufactured under these patents has this trade mark affixed. NONE GENUINE WITHOUT.

The advantages of the SPLITDORF WIRE over any other insulated wire are:

1st. A perfect insulation is obtained.

2d. All oxidation is prevented, and the wire and its conductivity are preserved against the deleterious effect of dampness.

3d. The outer covering (whether silk or cotton) adheres fast to the wire, and does not slip or unwind from the ends.

4th. A greater length of wire prepared under the SPLITDORF patents can be wound in a given space than wire insulated by any other process known.

5th. Since the strength of a magnet depends upon the number of its convolutions, SPLITDORF INSULATED WIRE will produce a much stronger magnet of a given size than any other wire in the market.

Wire covered with cotton by the SPLITDORF patents is fully equal in every respect to wire covered with silk under any other process, while SPLITDORF silk covered wire is far superior to the ordinary silk covered wire, in that so much finer silk can be used and such a decrease in bulk effected.

**Having increased our plant ten-fold, we shall be able to furnish wire at short notice. We manufacture all grades of wire, Magnet, Annunciator, Office, etc., etc.**

*SEND FOR OUR GENERAL CATALOGUE, ILLUSTRATED IN COLORS.*

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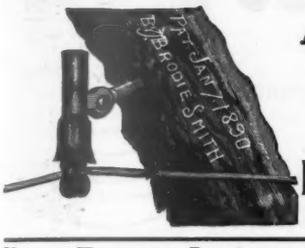
We cast Dynamo Magnets of a special mixture of iron that gives much better electrical results than ordinary castings. Also, small castings for Electrical Work, and castings large and small, for all purposes, of finest quality. OUR PRICES ARE LOW. We run four large cupolas constantly, melting about 35 tons daily. Correspondence solicited.

**SESSIONS FOUNDRY CO., Bristol, Conn.**

## THE BRODIE TREE INSULATOR




CAN BE SET
AT ANY ANGLE DESIRED,
MAKING ALWAYS
**Perfect Insulation for Wires,**
Manufactured and Sold by
**H. E. Swift Manufacturing Co.,**
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## New Tangye Buckeye Automatic Cut-off Engines.

In Use, Over 2,500.

25 to 1,000 H. P.

These engines are the combined result of long experience with automatic cut-off regulation, and most careful revision of all details. They are designed and constructed for heavy and continuous duty at medium or high rotative speeds. Highest attainable Economy in Steam Consumption and Superior regulation guaranteed. Self-contained Automatic Cut-off Engines 12 to 200 H. P. for driving Dynamo Machines a Specialty. Illustrated Circulars, with various data as to practical Steam Engine Construction and performance, free by mail.

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ELECTRIC LIGHT CARBONS.

MADE FROM NATURAL GAS BY PATENTED PROCESS.

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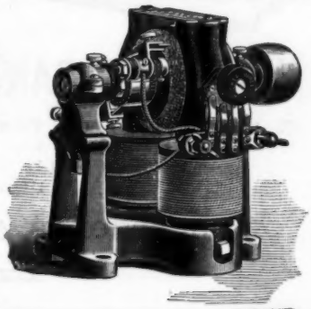
## THE CROCKER-WHEELER

PERFECTED
**MOTORS.**



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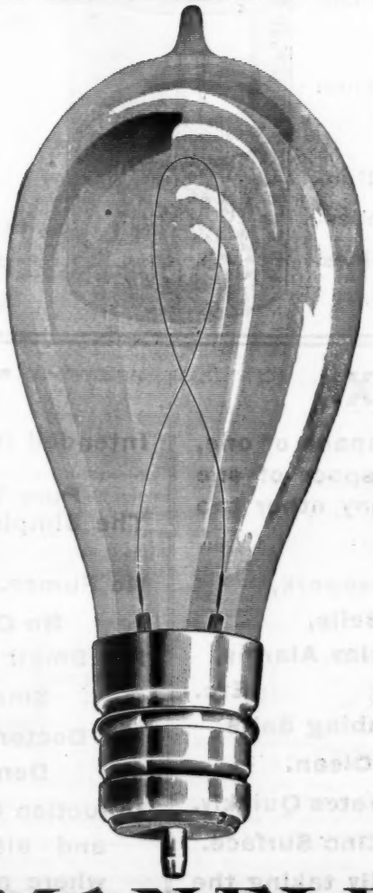
# INCANDESCENT LAMPS

To Fit any Socket.

Excelling all others in Life, Maintenance of Candle-Power and Efficiency.



Even Diffusion of Light by Twisted Filament.

From 8 Candle-Power to 150 Candle-Power and any Voltage.

# THE BEST IS

General Electrical Supplies of Superior Design and Finish.

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Send for Our Catalogue of August 1st, 1890.

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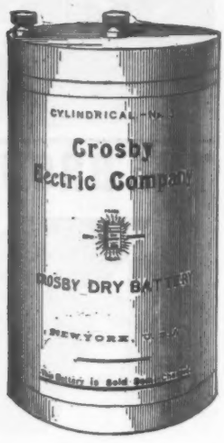
FOR OPEN CIRCUIT WORK.

ELECTRO-MOTIVE FORCE, 1.55 VOLTS. CURRENT, 1 TO 15 AMPERES.

RECTANGULAR, CYLINDRICAL, TELEPHONE.

MADE IN ALL SHAPES AND SIZES.

RECUPERATE OFTENER AND QUICKER THAN ANY OTHER.




**NEAT. = CLEAN. = EFFECTIVE. = SIMPLE. = COMPACT. = PORTABLE.**

IT IS THE BEST ON THE MARKET.
IT HAS MORE ADVANTAGES THAN ANY.
IT IS SOLD SEMI-CHARGED.
IT DOES NOT DIE ON THE SHELF.
IT IS NOT AFFECTED BY TEMPERATURE.
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IT IS THE MOST RELIABLE.
IT PERFORMS THE MOST WORK.

**FOR TELEPHONES, ANNUNCIATORS, GAS LIGHTING, HOUSEWORK, MEDICAL PURPOSES.**

PATENTED, JULY 2, 1889.

## THE HUSSEY BLUE STONE.

The Only Blue Stone Battery that can be used for open circuit work.

No Consumption of Blue Stone when not in use.

For Charging Storage Batteries, Running Sewing Machines, Small Incandescent Lamps, Fans, Dental Machines, Telegraphing.

Can be completely recharged without dismounting.

No Deposit of Copper on Zinc.

Gives 10 Times the Current of Any.

For Running Motors.

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**THIS IMPROVEMENT CAN BE APPLIED TO ALL FORMS OF BLUE STONE JARS AT PRESENT IN USE.**

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**Its two cells occupy only the space of one, thereby giving a voltage in the space of one cell, equal to that obtained by any other two cells requiring double the space.**

**For Housework,
Bells,
Burglar Alarms,
Etc.**

**No Climbing Salts.**

**Always Clean.**

**Recuperates Quickly.**

**Large Zinc Surface.**

**Is rapidly taking the place of all other Open Circuit Liquid Batteries.**

## THE ECLIPSE.

**Intended for Close Circuit Work.
Will Not Polarize.
Pure Water only Necessary to Charge It.
The Simplest and Cleanest Close Circuit Battery in the World.**

**No Fumes.
No Odor.**

**For Small Motors.
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**For Doctors' and Dentists' Use.**

**Induction Coils, Etc., and all purposes where a Constant Current is required for continuous or intermittent work.**